APPENDIX 3

Interpretive Report Comparing the Results of the Second No-flow Regime (1992/93) to the Intermittent Test Flow Regime (1990/91)

THE EFFECTS OF A WINTER NO-FLOW REGIME FROM THE CONOWINGO HYDROELECTRIC FACILITY ON MACROINVERTEBRATE POPULATIONS OF THE SUSQUEHANNA RIVER

Prepared for
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FOREWORD

This report, *The effects of a winter no-flow regime from the Conowingo Hydroelectric Facility on the macroinvertebrate populations of the Susquehanna River* was prepared by Versar, Inc., ESM Operations at the request of Dr. Richard McLean of the Maryland Department of Natural Resources, Power Plant Environmental Review Division under contract number PR91-047-001. The report presents analysis and results of a five year study accessing the impact of various winter flow regimes on the integrity of the macroinvertebrate community below the Conowingo Hydroelectric Facility. Results of this study will help state and utility officials reach an agreement on appropriate winter flow releases for future years.

This report consists of one volume containing the text and appendices A through E.

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1.0 INTRODUCTION

This report is the final in a series that presents results of macroinvertebrate sampling at the Conowingo Hydroelectric Facility. Macroinvertebrate sampling was initiated in the winter of 1988/89 to determine the effect of several different dam discharge regimes on the invertebrate community below Conowingo Dam during the winter months (the beginning of December to the end of February). Results of these studies are to be used by the state of Maryland and the Conowingo Power Company to determine what winter dam discharge regime is needed to protect and enhance aquatic resources below the dam.

1.1 BACKGROUND

The Conowingo Hydroelectric Facility, which is located about 10 miles upstream from the mouth of the Susquehanna River, is operated as a peaking unit, generating near capacity at times of high demand and reducing flows substantially during off-peak hours. Low flows during off-peak hours are of general ecological concern because organisms can be stranded or exposed to the atmosphere as a result of the sudden changes in water elevation (Cushman 1985). As part of the relicensing process for the Conowingo facility, the Philadelphia Electric Company (PECO) and the state of Maryland reached an agreement about appropriate continuous minimum flow releases to protect and enhance biota for the period between 1 March and 30 November (Appendix A). At the time of that agreement, no data were available to evaluate what minimum flow is necessary to protect biota during winter (1 December-28 February). As part of the settlement agreement, therefore, the state agreed to conduct studies to determine what flows are needed during the winter period.

The settlement agreement stipulated that three winter flow regimes should be evaluated for their relative ability to sustain benthic invertebrate populations below the dam. A different flow regime was to be maintained during each of three winters (1 December-28 February). The three flow regimes to be studied were

- a minimum flow of 3,500 cfs maintained continuously;
- a minimum flow of 3,500 cfs maintained intermittently with cessation of flow for up to six hours, provided that periods of no-flow were followed by continuous flows of 3,500 cfs for a period equal to or longer than the period of no discharge; and
- a regime of no minimum flow requirement, to be studied only if there were no demonstrable differences in the integrity of the benthic communities below the dam under the previously tested intermittent and continuous minimum flow regimes.

1.2 PREVIOUS STUDY RESULTS

Invertebrate sampling during the winter was initiated in 1988/89 under the minimum flow regime. Two habitat substrates, bedrock and gravel, were examined to evaluate flow effects on the macroinvertebrate population. The intermittent winter flow regime was studied in 1989/90. The results of the two-year comparison were inconclusive due to exceptionally high flows in January and February 1990, which precluded sampling during much of the study period (Appendix B, Weisberg and Scott 1990). A second year of the winter intermittent flow regime was tested in 1990/91. Based on a comparison between the intermittent flow year and the minimum flow year, the Conowingo Hydroelectric Facility was allowed to continue operating under an intermittent flow regime between December 1 and February 28 (Appendix B, Scott 1991).

The next step in the study was to determine if the facility could operate under a no-flow requirement without adversely affecting the macroinvertebrate population. A no-flow regime was studied during the winter of 1991/92, and the results were inconclusive. Although some of the key taxa appeared to be adversely affected by the no-flow regime in the bedrock habitat, abundances of all the key taxa in both substrates were extremely low throughout the study year (September 1991-February 1992), making it very difficult to determine if any changes had occurred (Appendix C). Since abundances of the key taxa were so low, state utility officials decided to repeat the no-flow regime test during the winter of 1992/93.

This report presents the results of the fifth and final year of winter macroinvertebrate sampling at Conowingo Hydroelectric Facility. The no-flow regime was examined and results were compared to the previous intermittent flow regime results.

2.0 METHODS

2.1 FIELD AND LABORATORY METHODS

A quantitative survey to measure densities of macroinvertebrate taxa below Conowingo Dam was conducted from 21 November 1992 through 27 February 1993. Sampling was initiated in November to establish a pre-experimental baseline during which biota below the dam were subjected to at least 9 months of continuous flows before the no-flow test regime. Samples were collected bi-monthly (Table 2-1).

Table 2-1. Macroinvertebrate sampling dates below Conowingo Dam during the winter of 1992/93

Sampling Dates Before Onset of No-flow Regime	Sampling Dates After Onset of No-flow Regime
November, 21 1992	December 19, 1992
December 5, 1992	January 24, 1993
	January 31, 1993
	February 13, 1993
	February 27, 1993

Samples were collected on the northeast side of Rowland Island at Transect D (Fig. 2-1). All samples were collected in a shoal area that is submerged at 3,500 cfs but exposed to the atmosphere at lesser flows. Releases from the dam were maintained at 5,000 cfs during sampling, with a one-hour acclimation period at this flow prior to sampling. Sampling was conducted at flows of 5,000 cfs to maintain conformity with historic studies (Weisberg and Janicki 1985) and to provide easier access to the sampling site. On each collection date, seven samples were collected from each substrate.

A 17.8-cm diameter T-sampler (Mackie and Bailey 1981) modified with a submersible pump was used to collected macroinvertebrate samples (Fig. 2-2). The sampler was positioned manually on the substrate, the pump turned on, and loose gravel scooped or bedrock scrubbed with a hand inserted through the nylon mesh. The pump was run for an additional 2 to 3 minutes after scooping or scrubbing to ensure that all organisms were captured in the sampler. The contents of the sampler were washed into a labeled jar and preserved in 10% buffered formaldehyde solution. In the

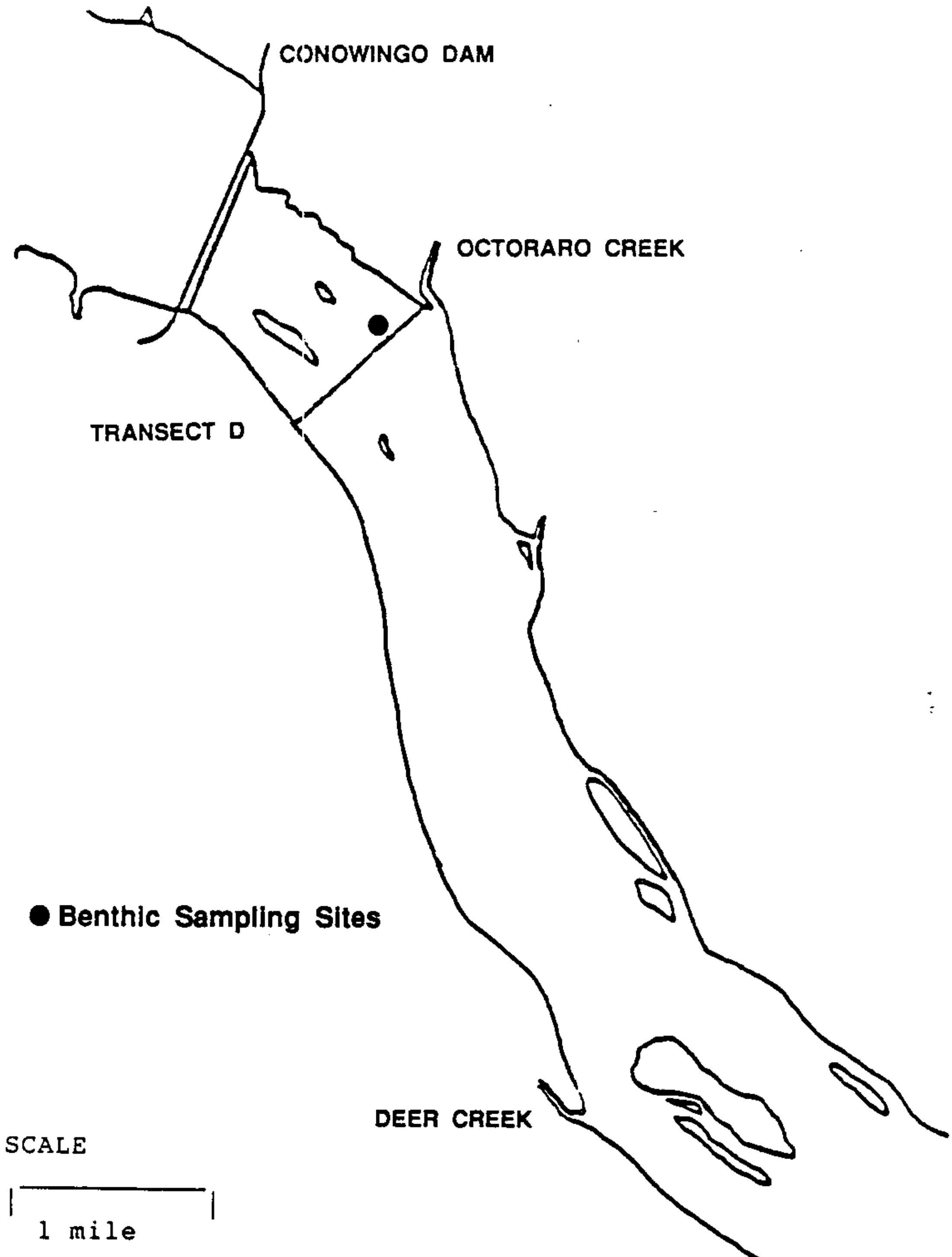

Fig. 2-1. Map of Susquehanna River below Conowingo Dam, showing location of sampling sites

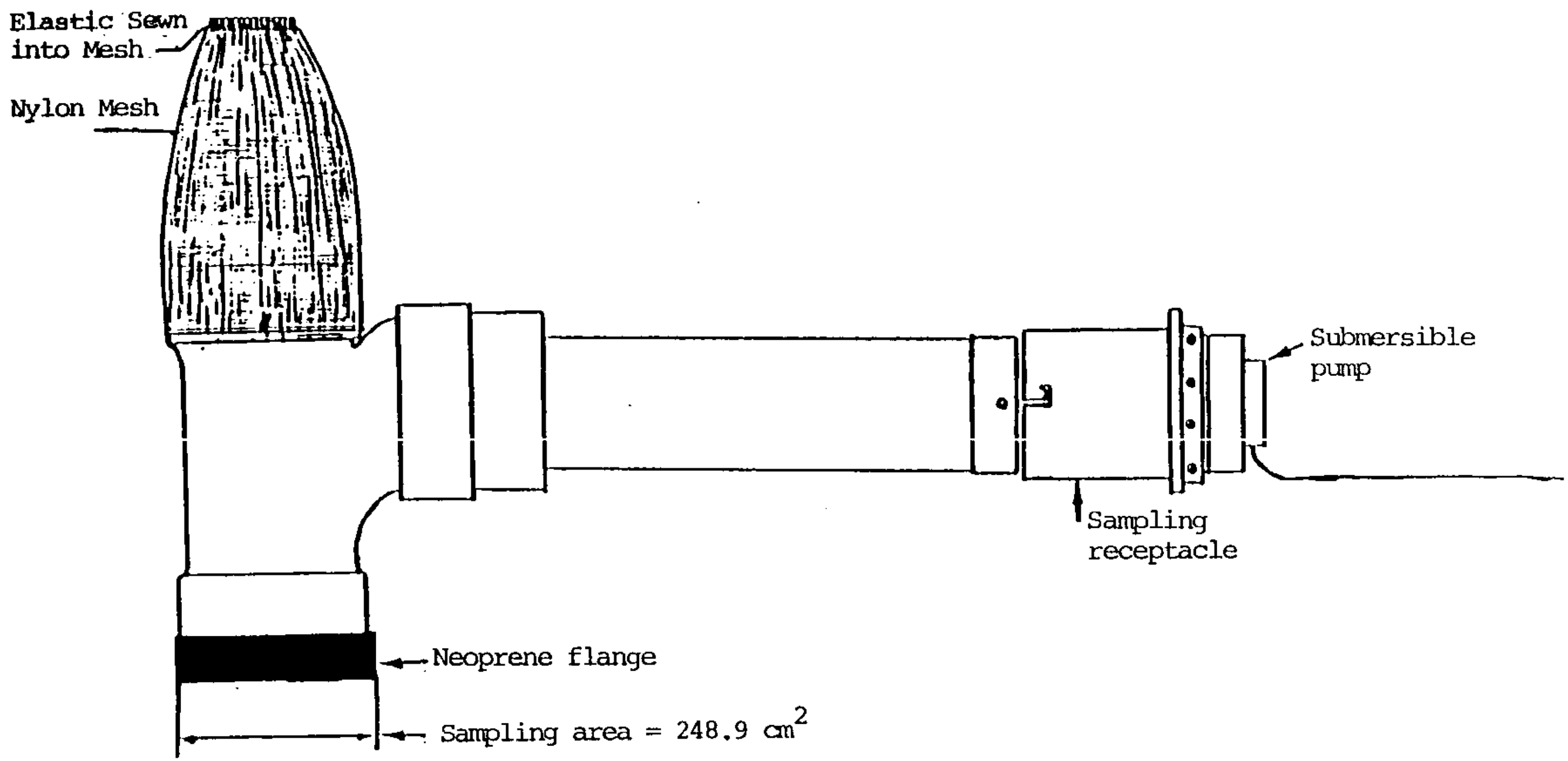

Figure 2-2. Modified T-sampler used in Conowingo benthic study (modified from Mackie and Bailey 1981)

laboratory, six samples were processed, and one was archived. Samples were washed through a 0.5-mm screen and sorted to separate organisms from debris. Macroinvertebrates were identified to the lowest practical taxonomic level without microscopic examination and enumerated.

2.2 ANALYTICAL METHODS

The purpose of the analyses was to determine if the effects of the no-flow regime on the macroinvertebrate population differed from those of the intermittent flow regime. Comparisons were made to the intermittent flow since the facility is currently operating under that flow regime during the winter period. One approach to interpreting effects was to visually examine the abundance graphs of three key taxa (gammarid amphipods, chironomid midge larvae, and hydropsychid caddisflies) and total macroinvertebrates for abundance differences at the end of the study period between the intermittent flow year (1990/91) and the no-flow test year (1992/93). These three taxa were examined because they are major prey for the resident summer fish populations (Weisberg and Janicki 1985). Graphical comparisons were based on differences in the macroinvertebrate abundances at the end of the test flow period. Data were analyzed separately for each substrate.

To statistically assess the differential effects of the two flow regimes, an analysis of covariance (ANCOVA) model was applied to data from the 1990/91 intermittent flow year and the second no-flow year (1992/93). Data from the 1989/90 and 1991/92 sampling years were not included in the analysis because the data were compromised for reasons stated in Section 1.2. The model was based on the assumption that the macroinvertebrate populations would experience an exponential change (either increasing, decreasing, or no change) from the time of implementation of the flow regime (approximately December 1) through the end of February.

The underlying model was:

$$N_t \quad = \quad N_o e^{*}t$$

where,

N_t = population size at time t (t units since December 1)

N_o = population size on December 1

Ψ = exponential survival parameter.

Methods based on ANCOVA were applied to macroinvertebrate abundance data obtained during the experimental period from approximately 1 December to the end of February. The purpose of the ANCOVA methods was to estimate the exponential survival parameter for the two different flow regimes and conduct a hypothesis test to determine if the survival parameters were significantly different. A significantly lower survival during the no-flow period would imply significantly greater mortality of benthic organisms during this flow regime. The ANCOVA analysis was based on the model

$$\log(C_{p,y,t,i}+1) = \mu + \gamma_p + \beta_{y(p)} + (\Psi_p * t) + \epsilon_{p,y,t,i}$$

where,

$C_{p,y,t,i}$	=	count of organisms in period p (p = 1,2), year y (y = 1-2), time t, and rep i
μ	=	overall mean log count
γ_p	=	parameter associated with average Dec. 1 abundance in period p
$\beta_{y(p)}$	=	parameter associated with average Dec. 1 abundance in year y within period p
Ψ_p	=	exponential survival parameter associated with period p
$\epsilon_{p,y,t,i}$	=	random error component.

Differential impacts due to flow regimes were determined by assessing a significant ($\alpha = 0.1$) difference between the exponential survival parameters for each period. Alpha was set at the 0.1 level due to the highly variable nature of macroinvertebrate abundance data. Typically, an alpha of 0.05 is used in well-controlled laboratory experiments but, since this is a field study with many uncontrolled variables affecting results, an alpha of 0.1 is acceptable. Statistical analyses addressed total macroinvertebrate abundance, as well as the abundances of individual taxa that constituted at least 5% of total macroinvertebrate abundance in either substrate in any study year. Data were analyzed separately for each substrate.

To interpret the statistical results, the assumption that flow effects are greater than year-to-year effects needed to be tested. Since the study design did not allow for control or reference sites to help determine year effects the only way to test this assumption was to apply the ANCOVA model to data from combinations of other years. Specifically, the ANCOVA model was applied to the 1988/89 (minimum flow) and the 1990/91 (intermittent flow) mortality rates and the 1988/89 and 1992/93 (no-flow) mortality rates.

3.0 RESULTS

The results of applying the ANCOVA model to other combinations of yearly data suggest that flow effects are greater than year-to-year effects. Eight of the 22 (36%) statistical comparisons between the intermittent year and the no-flow year were significantly different (Table 3-1, Appendix D). Only four (18%) of the 22 statistical comparisons between the minimum flow and the no-flow regimes and two (9%) between the minimum flow and intermittent flow regimes were significant (Appendix E). Therefore, the assumption that flow effects are greater than year effects appears valid.

3.1 BEDROCK HABITAT

Total abundance and the abundances of the three key taxa examined for this study were substantially lower at the end of the no-flow regime than at the end of the intermittent flow regime (Figs. 3-1 to 3-4). Total abundance was an order of magnitude lower at the end of the second no-flow year (1992/93) than at the end of the intermittent flow year (Fig. 3-1). The mortality rate of the total macroinvertebrate community was significantly greater under the no-flow regime than under the intermittent regime (Table 3-1, Appendix D). Gammaridae were two orders of magnitude less abundant at the end of the second no-flow year compared with the intermittent year (Fig. 3-2). Hydropsychidae and Chironomidae were more than four times less abundant at the end of the second no-flow year (Figs. 3-3 and 3-4). Hydropsychidae exhibited significantly higher mortality during the no-flow regime whereas Gammaridae and Chironomidae mortality rates were not significantly different (Table 3-1). Abundances of the three key taxa before the onset of the no-flow regime (i.e., pre-test regime period) were similar to those before the onset of the intermittent flow regime. Other taxa that exhibited higher mortality during the no-flow regime included the worms Oligochaeta and *Manayunkia speciosa* (Table 3-1). The nuisance bivalve *Corbicula fluminea* and the limpet *Ferrissia rivularis* had significantly higher mortality under the intermittent flow regime (Table 3-1).

3.2 GRAVEL HABITAT

Total abundances in the gravel substrate were similar at the end of the second no-flow year and the intermittent flow year (Fig. 3-5). Abundances of two of the key taxa in this substrate were substantially higher at the end of the no-flow year (Figs. 3-6 to 3-8). Hydropsychidae and Gammaridae were approximately three times more abundant at the end of the second no-flow year than at the end of the intermittent year (Figs. 3-6 and 3-7), whereas Chironomidae were approximately 2.5 times less abundant at the end of the second no-flow year (Fig. 3-6). Gammaridae mortality rates were significantly higher in the intermittent flow year than in the second no-flow year (Table 3-1, Appendix D). The mortality rate of the total macroinvertebrate community and the other key taxa were not significantly different between the intermittent flow and the no-flow regimes (Table 3-1).

Table 3-1. Results of statistical analysis examining mortality rates from the two different winter flow regimes. A (+) indicates a significantly ($\alpha=0.1$) higher mortality rate under the no-flow regime and a (-) indicates a significantly higher mortality rate under the intermittent flow regime.

Taxa	Bedrock	Gravel
Total Abundance	+	NS
Chironomidae	NS	NS
Hydropsychidae	+	NS
Gammaridae	NS	-
Oligochaeta	+	NS
Manayunkia speciosa	+	NS
Prostoma rubrum	NS	NS
Dugesia tigrina	NS	+
Menetus sp.	-	NS
Corbicula fluminea	-	NS
Ferrissia rivularis	NS	NS

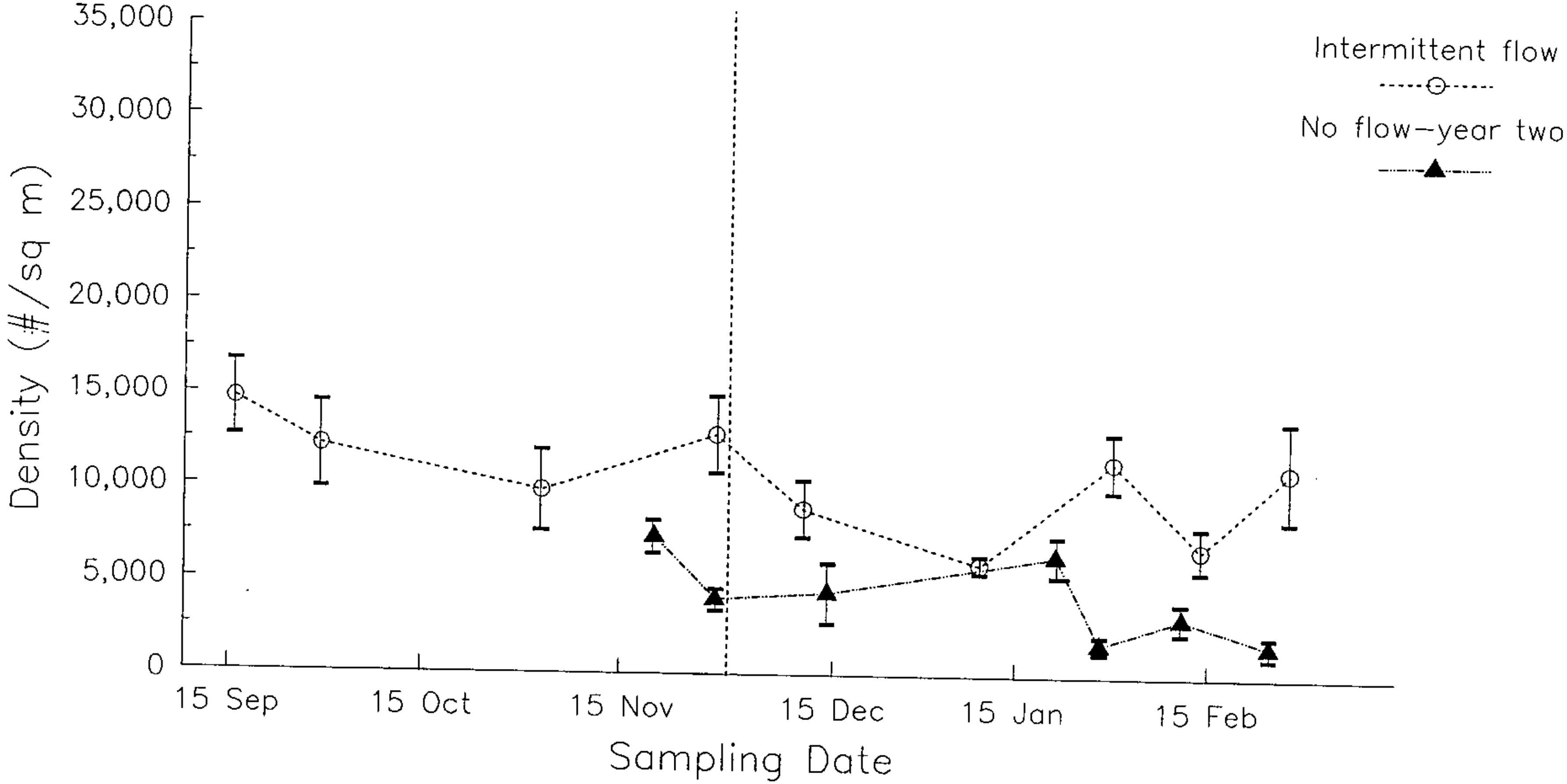

Figure 3-1. Mean density of total macroinvertebrates ($\pm$ 1 STD) from the bedrock substrate below Conowingo Dam. The vertical dashed lines indicates the onset of the test period.

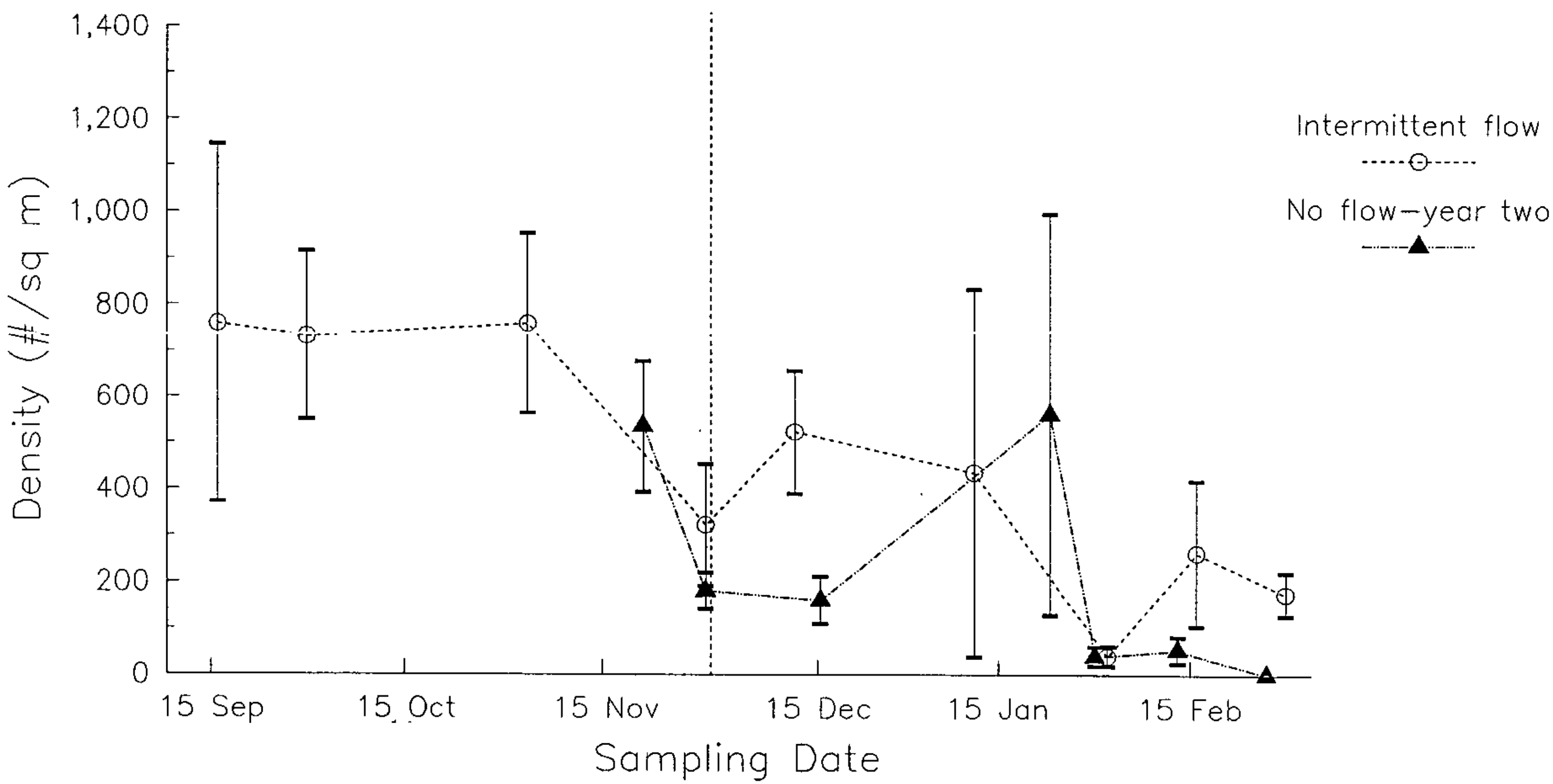

Figure 3-2. Mean density of Gammaridae (± 1 STD) from the bedrock substrate below Conowingo Dam. The vertical dashed lines indicates the onset of the test flow regime period.

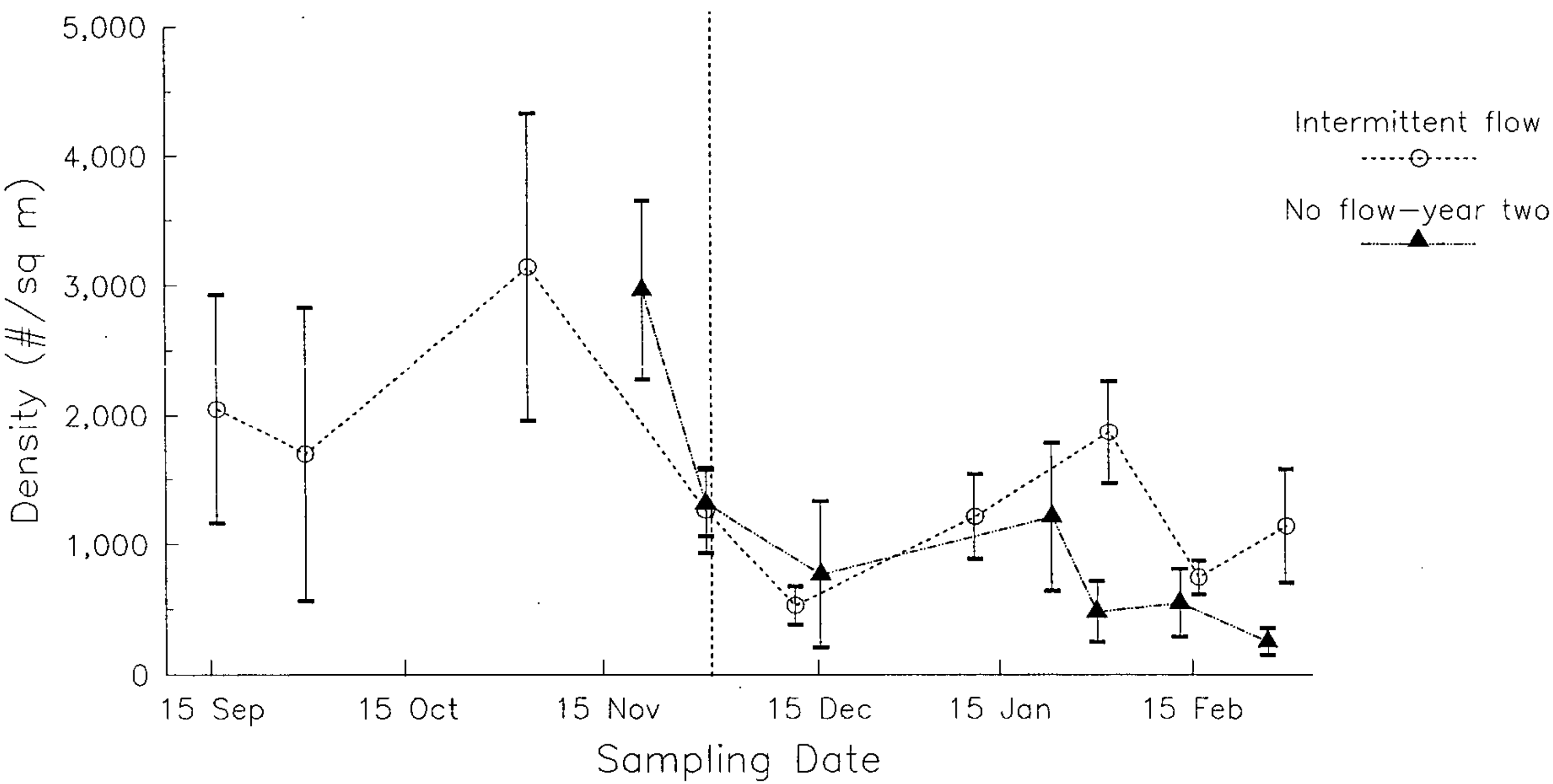

Figure 3-3. Mean density of Hydropsychidae ($\pm$ 1 STD) from the bedrock substrate below Conowingo Dam. The vertical dashed lines indicates the onset of the test flow regime period.

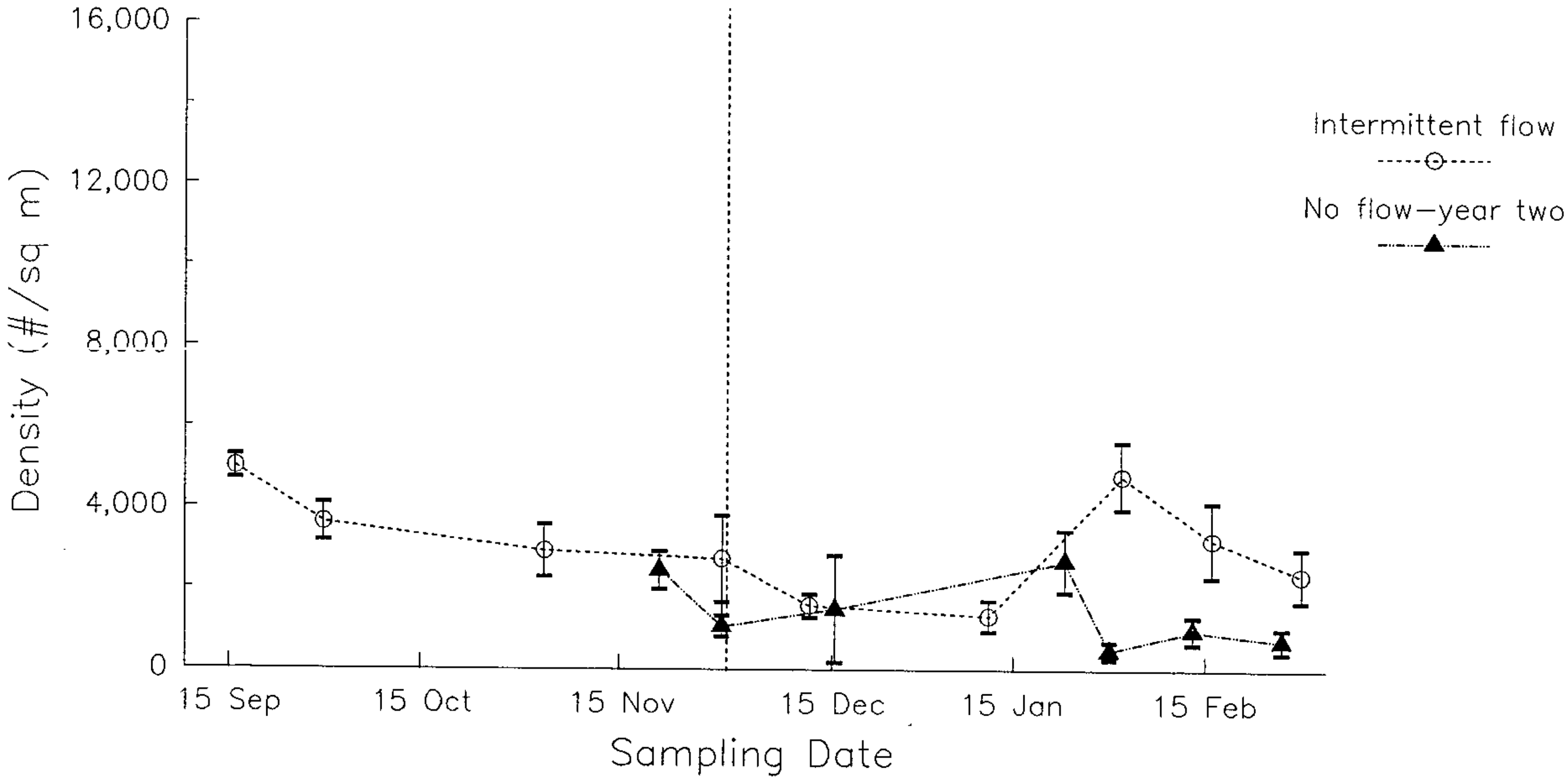

Figure 3-4. Mean density of Chironomidae ($\pm$ 1 STD) from the bedrock substrate below Conowingo Dam. The vertical dashed lines indicates the onset of the test flow regime period.

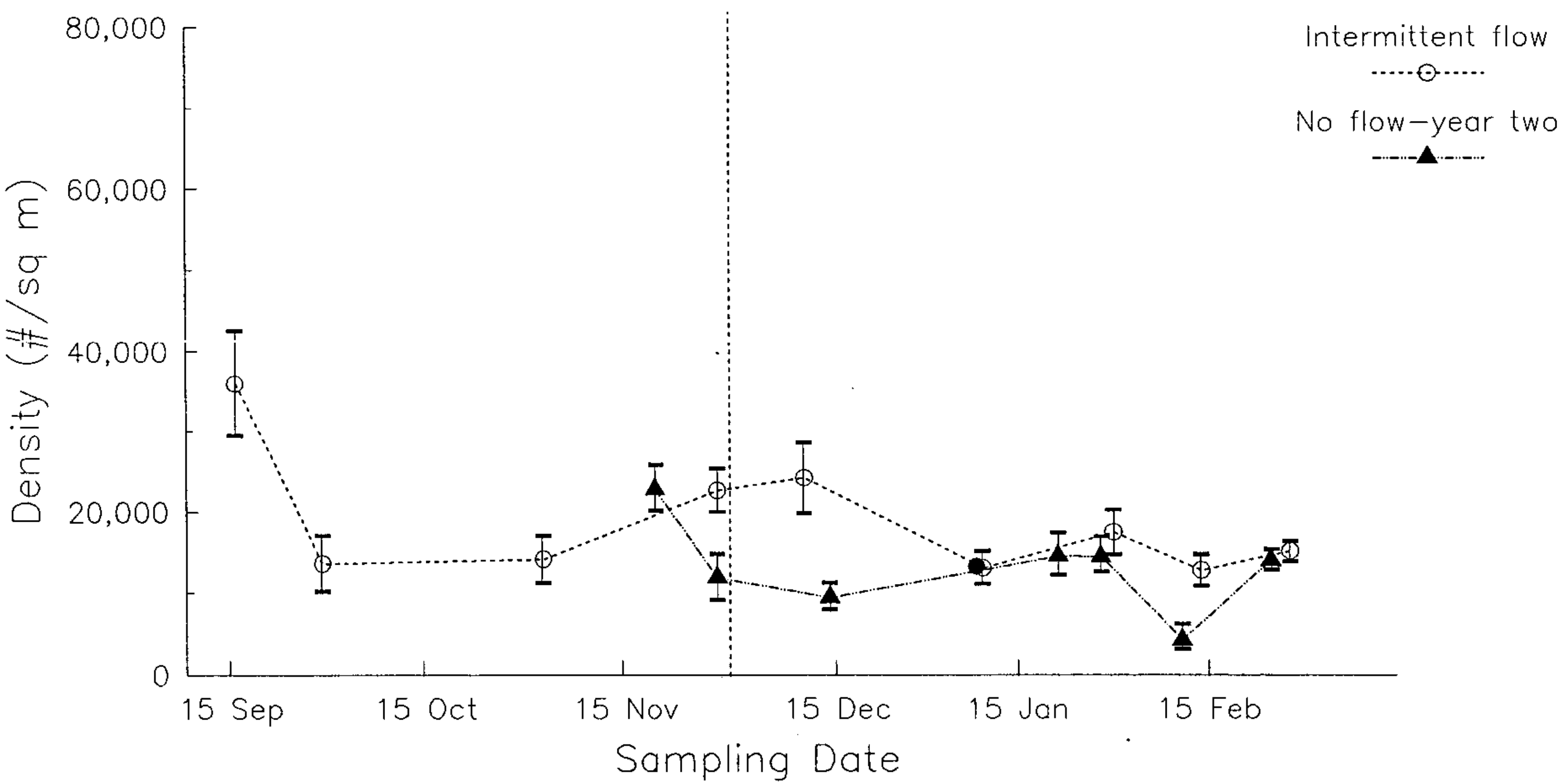

Figure 3-5. Mean density of total macroinvertebrates ($\pm$ 1 STD) from the bedrock substrate below Conowingo Dam. The vertical dashed lines indicates the onset of the test flow regime period.

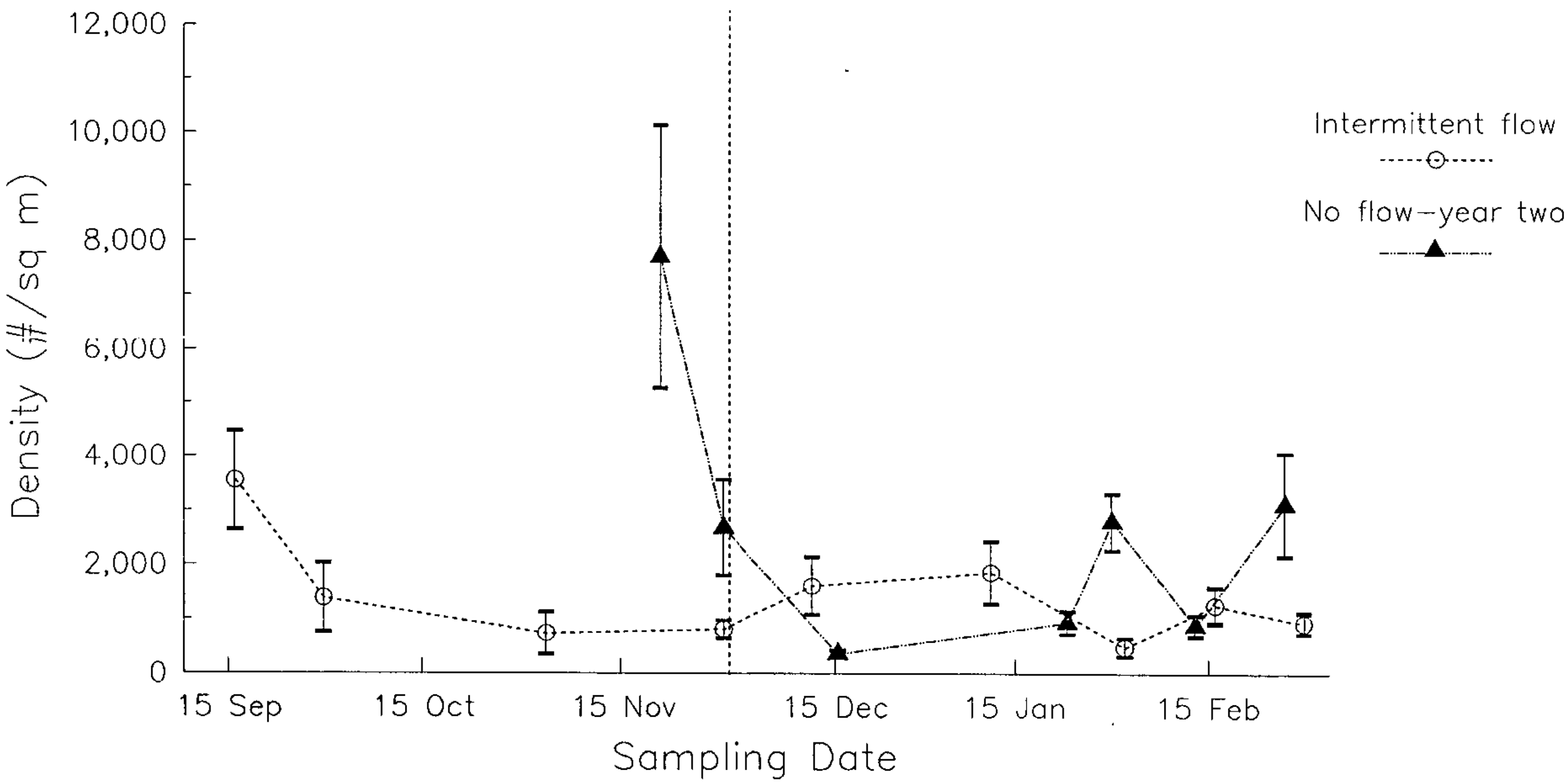

Figure 3-6. Mean density of Hydropsychidae ($\pm$ 1 STD) from the bedrock substrate below Conowingo Dam. The vertical dashed lines indicates the onset of the test flow regime period.

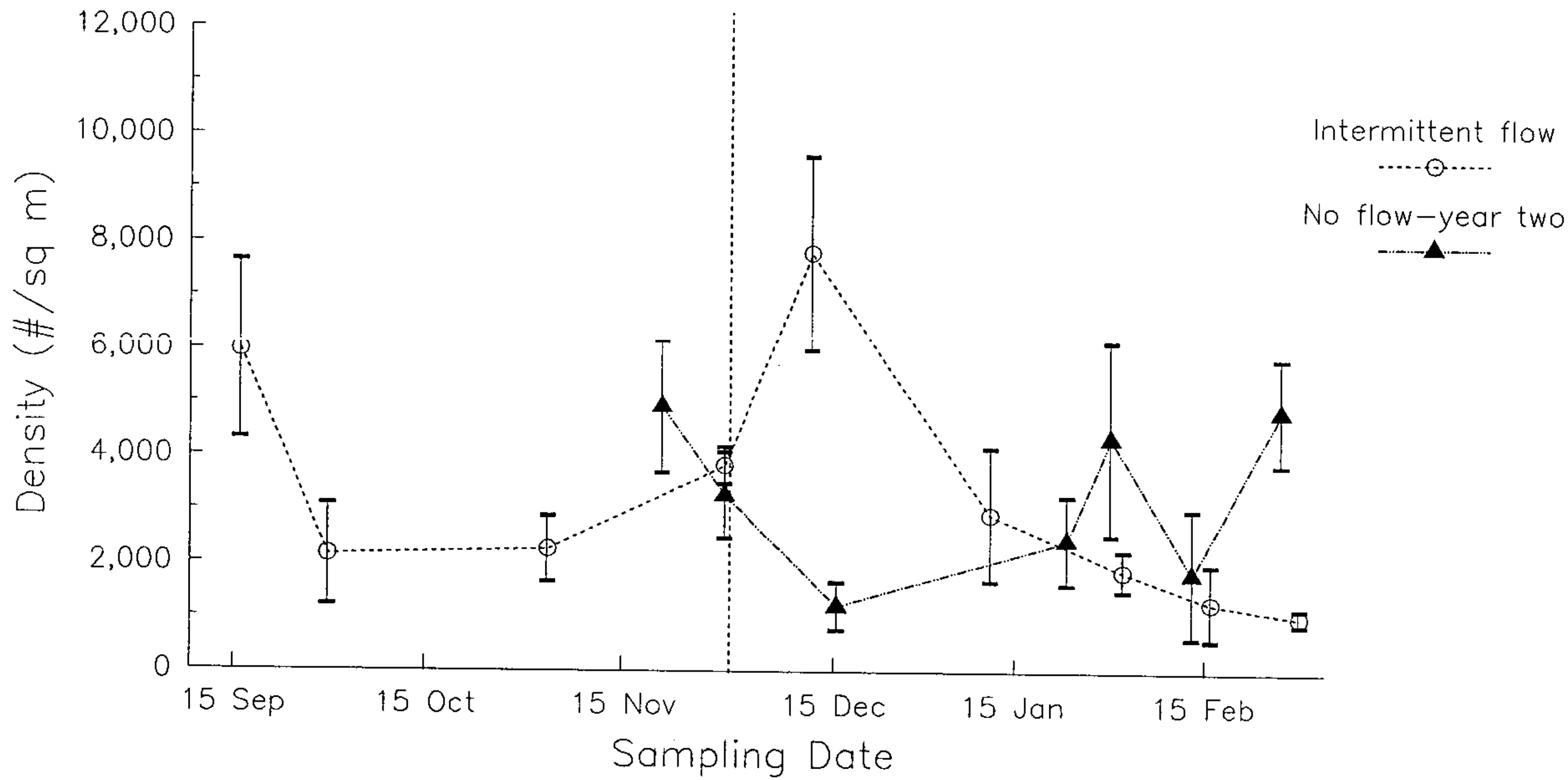

Figure 3-7. Mean density of Gammaridae ($\pm$ 1 STD) from the bedrock substrate below Conowingo Dam. The vertical dashed lines indicates the onset of the test flow regime period.

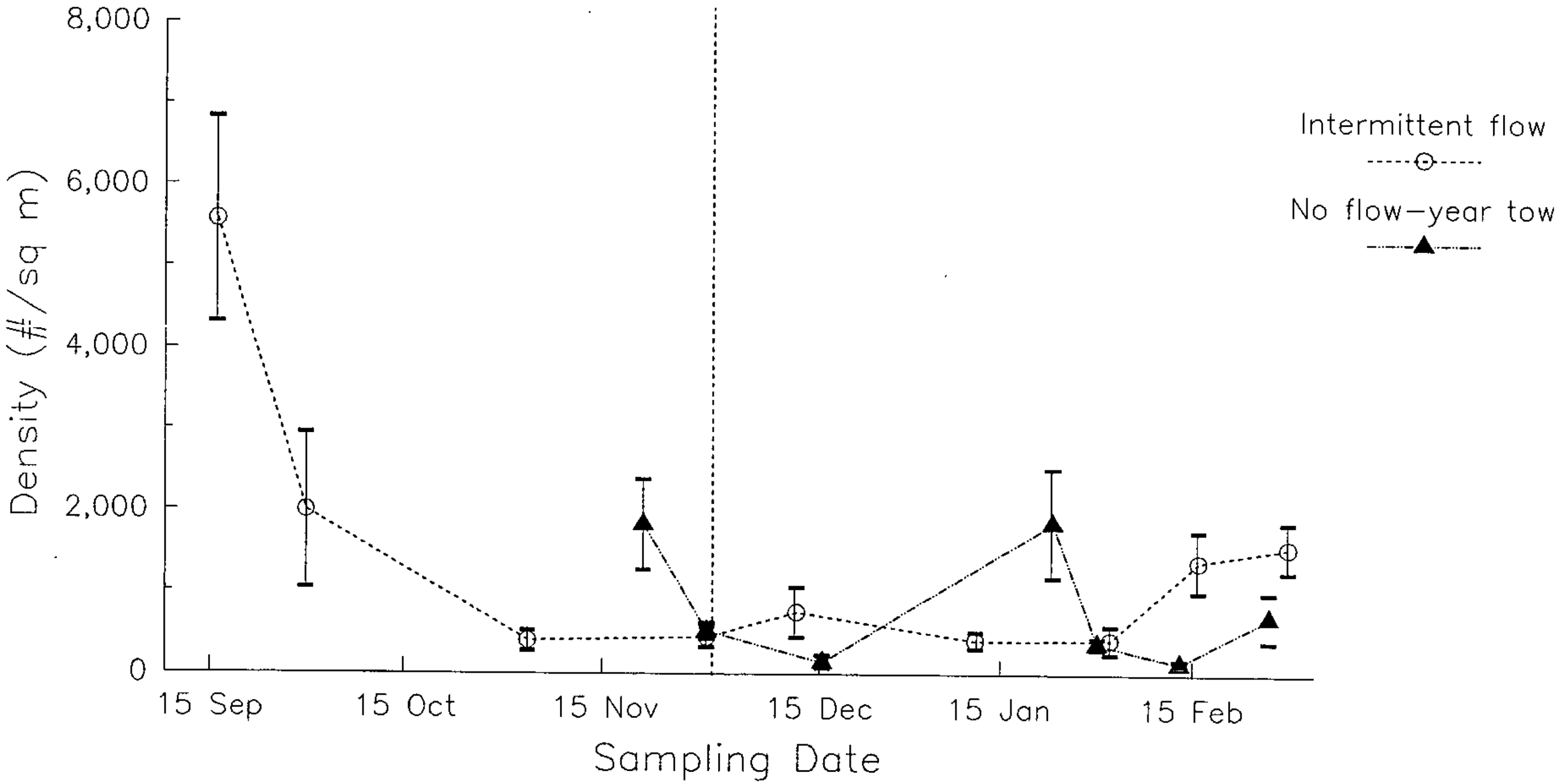

Figure 3-8. Mean density of Chironomidae ($\pm$ 1 STD) from the bedrock substrate below Conowingo Dam. The vertical dashed lines indicates the onset of the test flow regime period.

4.0 SUMMARY

The sampling design employed for this study had a serious weakness in that flow effects on the macroinvertebrate community were confounded with year effects. The study was implemented with these limitations in the interest of reaching a final decision about winter flows within a reasonable length of time (a rigorous study designed to account for annual effects and examining three flow regimes could take 15 to 20 years). Adverse effects of the no-flow regime would be harder to detect due to this confounding of flow and year effects. For this reason, the philosophy of the study agreement was to look for "obvious" effects rather than for small but statistically significant changes.

The potentially confounding annual effect was acknowledged at the beginning of the study, and every attempt was made to correct for it. For example, when the data were compromised (i.e., missing data points due to high flows or unusually low abundances of key taxa) the test of the flow regime was repeated, and the year with compromised data was not used in the analysis. For this reason, only one year of data from each flow regime was used in the analysis. To test whether the year-to-year effects were greater than the flow effects, the ANCOVA model was applied to data from combinations of other years with acceptable data. This is not the most rigorous test for year effects but is the only one available given the study design. Nonetheless the analysis indicated that flow effects were greater than year effects. Of the 22 combinations of species and substrate examined in the comparison of the minimum and intermittent flows, only two were significant. In the comparison of the minimum and no-flow regimes, four of the 22 tests were significant. Eight of the 22 tests were significant in the comparison of the intermittent and no-flow regimes. This additional analysis only partly ensures a reasonable test. Multiple years of data under each flow regime would have been most desirable; however, as stated previously, a rigorous study design was not appropriate given the management constraints.

In the bedrock habitat, the winter no-flow regime appears to have adversely affected the abundances of all three key taxa and total abundance at the end of the study period. The effect of the no-flow regime was demonstrated by order of magnitude decreases in total macroinvertebrate abundance and abundance of hydropsychid caddisflies, and the four-fold decreases in the abundance of chironomid midges and gammarid amphipods at the end of the no-flow regime. Furthermore, four of the eleven taxa examined for mortality trends had significantly higher mortality in the no-flow year, including total abundance and Hydropsychidae abundance.

In the gravel habitat, Hydropsychidae and Gammaridae abundances were higher at the end of the no-flow regime than at the end of the intermittent regime. What is unclear is whether these organisms moved into the gravel habitat in order to take refuge from desiccation in the bedrock habitat. Unfortunately, the study design could not address this question. If these individual taxa abundances increased due to the organisms seeking refuge from desiccation, the increase did not appear in the total macroinvertebrate abundance. Total abundance was approximately the same between the intermittent and no-flow regimes. Under the no-flow regime, significant decreases in the bedrock habitat occurred in four of the eleven comparisons, whereas only one of the eleven comparisons increased in the gravel habitat.

Even with the study limitations, the data demonstrate that the winter no-flow regime is causing substantial decreases in the populations of important prey taxa in the bedrock habitat (i.e., hydropsychid caddisflies, chironomid midges, and gammarid amphipods). The hydropsychid caddisflies, which had significantly higher mortality rates during the no-flow regime, account for as much as 80 % of the diet biomass for the summer resident fish populations below the hydroelectric facility (Weisberg and Janicki 1985). The gammarid amphipods and the chironomid midges, which also demonstrated large population decreases due to the winter no-flow regime in the bedrock habitat, account for 38% of the diet biomass for yellow perch and 31% of the diet biomass of channel catfish in the summer (Weisberg and Janicki 1985).

Fish sampling and tagging studies below the dam indicate that many important fish species leave the tailrace in the fall before the onset of the winter flow regime. The effect of the winter loss of prey items on these fish populations when they return to the system is unclear; however, the loss cannot be dismissed. Year-to-year differences do not explain all of the statistically significant effects observed between the no-flow and intermittent flow regimes. When other year combinations were compared, less than 18% had significant mortality differences. The frequency of significant differences between the intermittent and no-flow regimes in the relevant years was double (36%) the frequency in other year comparisons, which suggests that flow is affecting species abundances. Furthermore, in the bedrock habitat more than 50% of the taxa were significantly affected by the no-flow regime.

5.0 REFERENCES

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APPENDIX A
CONOWINGO SETTLEMENT AGREEMENT

AGREEMENT OF TECHNICAL ISSUES
AT CONOWINGO DAM
MARYLAND DEPARTMENT OF NATURAL RESOURCES
PHILADELPHIA ELECTRIC POWER COMPANY
THE SUSQUEHANNA POWER COMPANY

The following agreement between the Department of Natural Resources (DNR), of the State of Maryland, and Philadelphia Electric Power Company, and The Susquehanna Power Company, licensees of the Conowingo Hydro-electric Project (Licensees), resolves all issues in the pending Conowingo Project proceedings before the Federal Energy Regulatory Commission (FERC). This agreement will be presented to all parties to the pending Conowingo Project proceedings and shall form the basis of a settlement agreement to terminate these pending proceedings (hereinafter the Settlement Agreement).

WATER QUALITY

1. DNR, and Licensees agree to submit a joint letter to FERC requesting immediate approval of Licensees plan filed with FERC on June 29, 1987, (hereinafter the Plan), for meeting the applicable Maryland water quality standard for dissolved oxygen of 5.0 mg/liter (hereinafter the D.O. Standard) in the Susquehanna River below the Conowingo Dam

(to be measured at Shure's Landing). If FERC approves the Plan by April 1, 1988, Licensees agree to the conditions in paragraphs 2 through 5 below.

2. In order to adhere to the schedule described in the Plan, Licensees agree to make every effort to install a turbine venting system on one unit by August 1, 1988, on two additional units by August 1, 1989, on two additional units by August 1, 1990, and to complete all such installations by August 1, 1991. Each turbine venting system will allow for the introduction of bottled oxygen, as described in the Plan. A compressed air system at the intakes will also be installed as described in the plan. Both systems shall be used if necessary to meet the D.O. Standard.

3. When necessary to meet the D.O. Standard, Licensees will operate the four newer units (singly or in combination) at less than efficient gate with vacuum breakers open.

4. During calendar year 1988, if: (1) the measure described in paragraph 3 above, operating alone or in combination with the first turbine venting and compressed air system, does not cause the discharge to meet the D.O. Standard; and (2) the D.O. level in the Susquehanna River measured at Shure's Landing falls below 4.0 mg/liter, then the Licensees will declare that a D.O. emergency event has occurred. Licensees will notify designated representatives

of the State of Maryland. If the Pennsylvania-New Jersey-Maryland Interconnection (PJM) has not declared a Maximum Emergency Generation condition, then the Licensees shall conduct a monitored spill at a rate of flow of 4000 cfs in addition to sufficient turbine releases to maintain the required minimum flow rate. If D.O. levels do not improve, then with concurrence from designated representatives of the State of Maryland, Licensees may discontinue the spill for that event. The standards to be used for monitoring the spill, for determining that D.O. levels are not improving, the duration of the spill, and the length of time before another event shall be declared, will be subsequently agreed upon by the parties hereto and will be included in the Settlement Agreement.

5. During calendar year 1989 and subsequent years, if: (1) the measure described in paragraph 3 above, operating alone or in combination with the turbine venting and compressed air systems, does not cause the discharge to meet the D.O. Standard; and (2) the D.O. Level in the Susquehanna River measured at Shure's Landing falls below 5.0 mg/liter, then a D.O. emergency event will be declared and all conditions specified in paragraph 4 will apply.

MINIMUM FLOWS

1. The following schedule of minimum flows at Conowingo Dam, has been agreed upon by the parties hereto and is to begin on March 1, 1988, or upon approval by FERC of the Settlement Agreement, whichever occurs later. These flows represent turbine releases and do not include leakage.

DATE	MINIMUM FLOW
March 1 - March 31	3,500 cfs
April 1 - April 30	10,000 cfs
May 1 - May 30	7,500 cfs
June 1 - September 14	5,000 cfs
September 15 - November 30	3,500 cfs
December 1 - February 28	3,500 cfs**

** Studies will be implemented by DNR to determine if continuous flows have a detectable impact on benthic populations in the Susquehanna River below the Dam. Benthic population inventories will be conducted during continuous flows for the winter of 1988-89 and during interrupted flows for the winter of 1989-90, such interruptions not to exceed six hours followed by continuous flows for a period equal to or greater than the period interrupted. DNR will recommend the study methods to be included in the Settlement Agreement. DNR will review the results with Licensees periodically. If the populations are not adversely affected by the interrupted flows, they will be monitored during the winter of 1990-1991 under a regime of no minimum flow. If DNR determines by these studies that the populations are not adversely affected, Licensees and DNR agree that continuous winter minimum flows (December, January, February) will not be required in future years.

2. In all cases, the minimum required flows shall not exceed the unregulated Susquehanna River flow measured at the U.S. Geological Survey Station at Marietta, Pa.

3. When PJM declares an Operating Reserve Capacity Warning and/or Maximum Emergency Generation, or a three day forecast of such condition(s), DNR agrees that minimum flows may be reduced, with concurrence from their designated representative. This reduction will be balanced with a reduction in scheduled pond level according to a schedule to be subsequently agreed upon by the parties hereto and to be included in the Settlement Agreement. Flows will not be

reduced below 3,500 cfs except as provided in paragraphs 1 and 2 above.

Licensees and DNR agree that all biological (instream flow incremental methodology) studies previously ordered by FERC for the determination of minimum flows shall no longer be required.

PERMANENT FISH PASS FACILITY

1. Licensees are committed to the permanent restoration of fish populations in the Susquehanna River. Licensees agree that they will seriously consider the construction of a permanent fish passage facility instead of the FERC ordered second fish lift according to the following schedule:

January 11, 1988	DNR will solicit approval of the concept from the Intervenors and will inform Licensees of the agreements reached.
March 1, 1988	The Intervenors will provide to Licensees conceptual plans describing size, type, and location of the desired fish passage facility.

July 1, 1988	Preliminary engineering design and costs will be submitted to DNR and the Intervenors by Licensees. At this time Licensees will determine if they are willing to go ahead with final design and construction. If cost exceeds that which Licensees are reasonably willing to spend, DNR agrees to explore the possibility of additional funding.

2. If it is determined that the permanent facility will not be built, Licensees will construct the second fish lift, as presently ordered by FERC. Licensees will make a reasonable effort to design the second fish lift to be compatible with operation as a permanent facility.

3. If it is determined that the permanent facility will not be built, but the delay caused by Licensee's planning for, and consideration of, such facility results in the second fish lift not being operational by April 15, 1989, Licensees agree to contribute, in 1989, $100,000 to the Susquehanna River Anadromous Fish Restoration Committee (SRAFRC) toward the construction of an impoundment facility of a design and at a location determined by SRAFRC, or some other activity determined by SRAFRC related to the adult fish transfer project at Conowingo. In addition, to further

mitigate the effects of the delay, Licensees agree to continue operating both fish lifts, including trucking of fish to upstream locations, for one year beyond the end of the Upstream Utilities Settlement Agreement.

DNR and Licensees recognize that this settlement may or may not result in construction of a permanent facility at this time. Because the final decision on this issue will not be made until at least July 1, 1988, DNR and Licensees agree that implementation of the agreements on flows and dissolved oxygen will not be delayed until final resolution of this issue.

EFFECTIVE DATE

This agreement shall become effective upon approval of the Settlement Agreement consistent herewith by FERC.

SIGNED:

Tony C. Brown MD
Secretary, Maryland
Department of Natural
Resources

2/17/88
Date

Vice President
Philadelphia Electric
Power Company

Vice President
The Susquehanna Power Company

Date

APPENDIX B
SELECTED GRAPHICS REPRESENTING RESULTS FOR KEY TAXA FROM WEISBERG AND SCOTT (1990) AND SCOTT (1991)

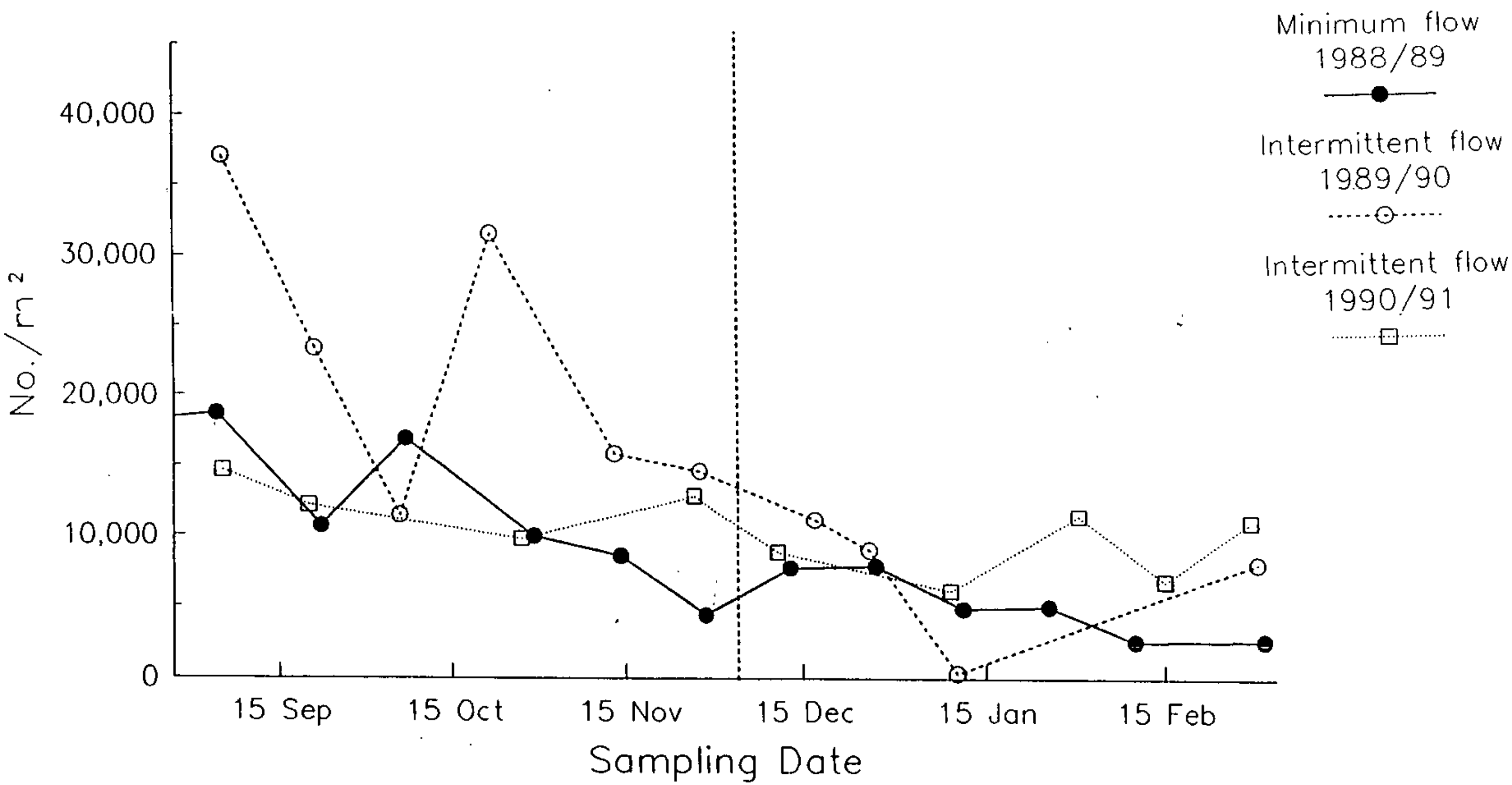

Figure B-1. Total mean abundance of macrobenthos collected from bedrock substrate below Conowingo Dam. The dashed vertical line indicates the date of onset of the experimental flow period.

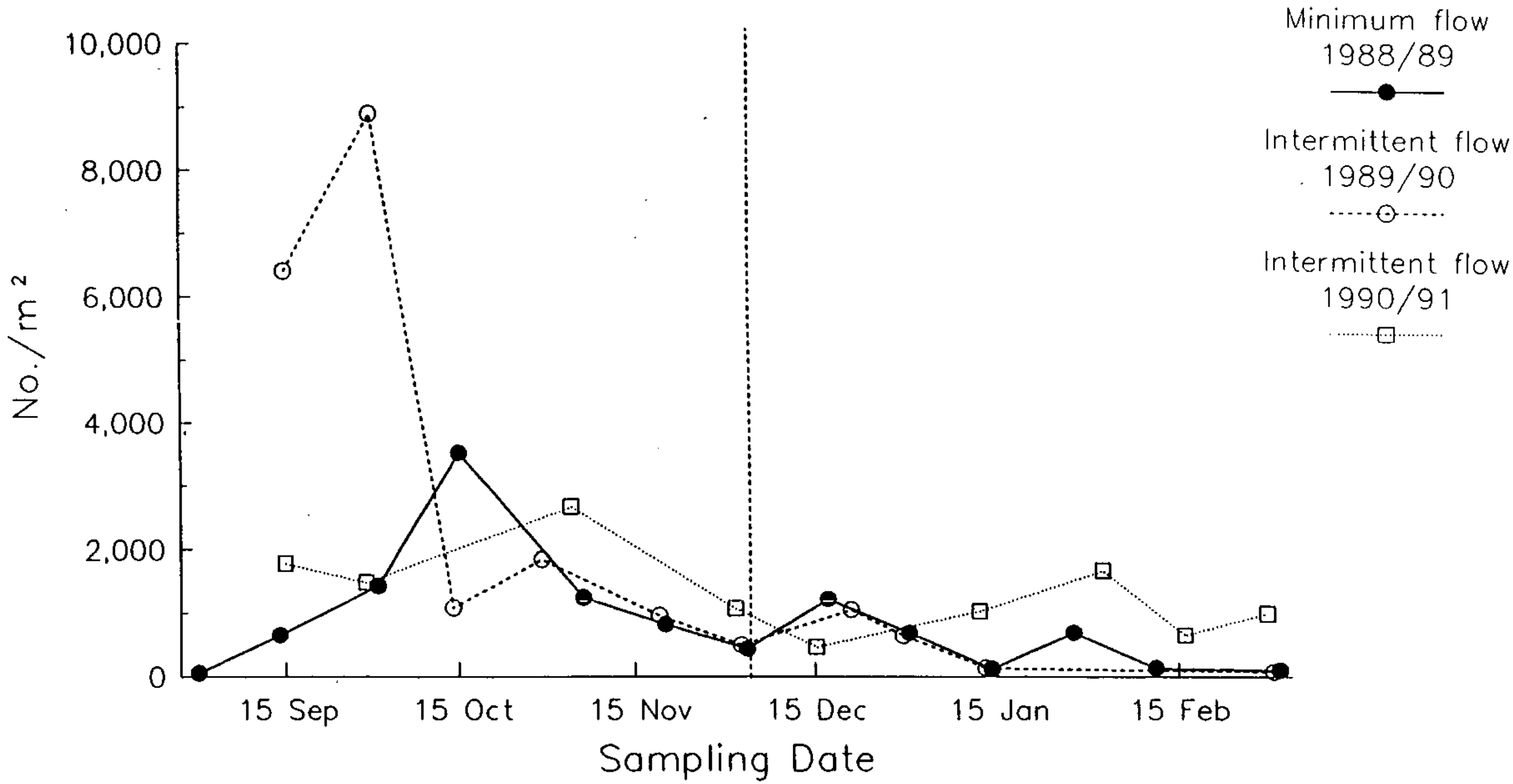

Figure B-2. Mean density of *Cheumatopsyche* sp. (caddisfly) from bedrock substrate below Conowingo Dam. The dashed vertical line indicates the date of onset of the experimental flow period.

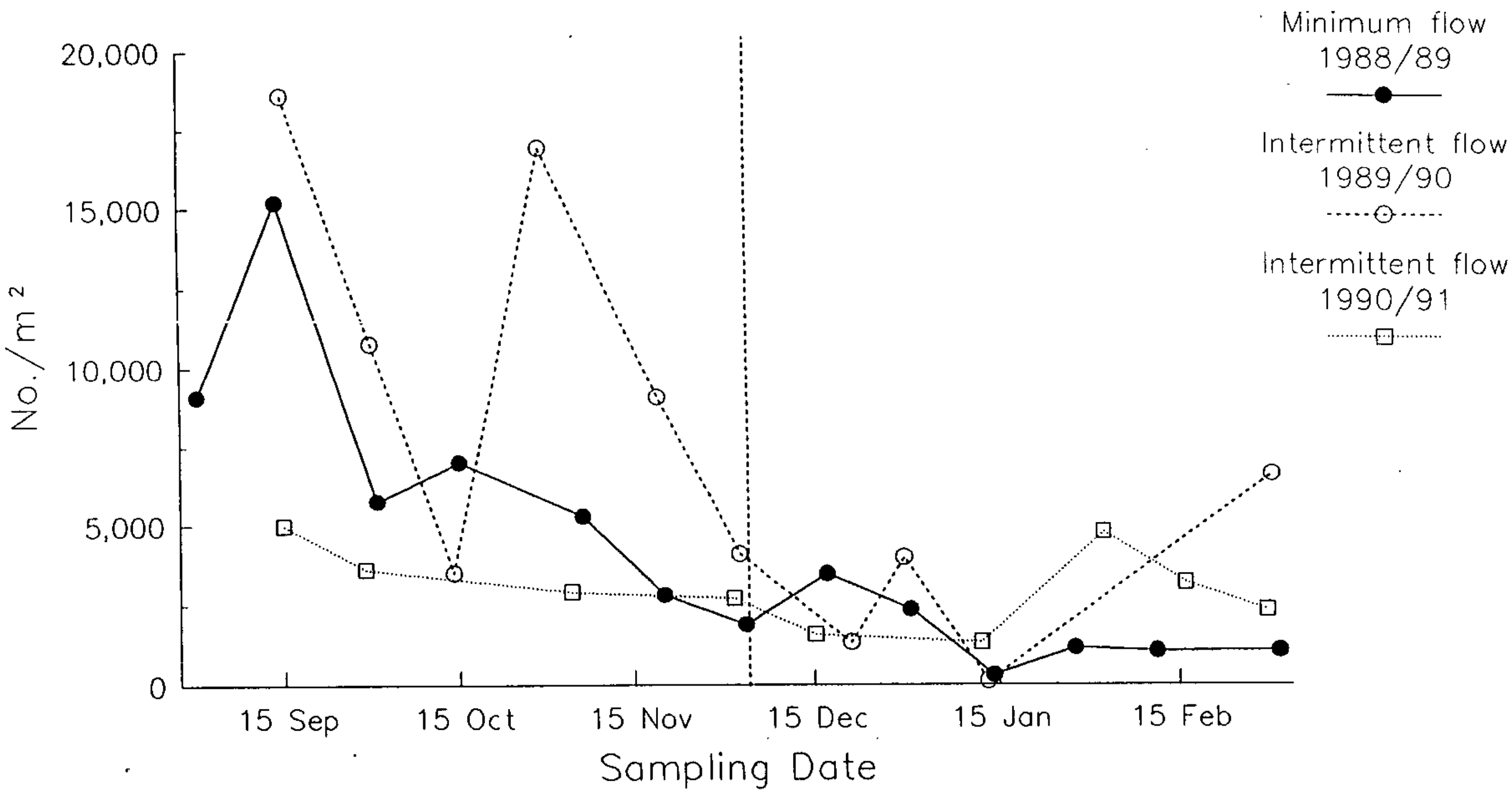

Figure B-3. Mean density of *Chironomidae* (midge) from bedrock substrate below Conowingo Dam. The dashed vertical line indicates the date of onset of the experimental flow period.

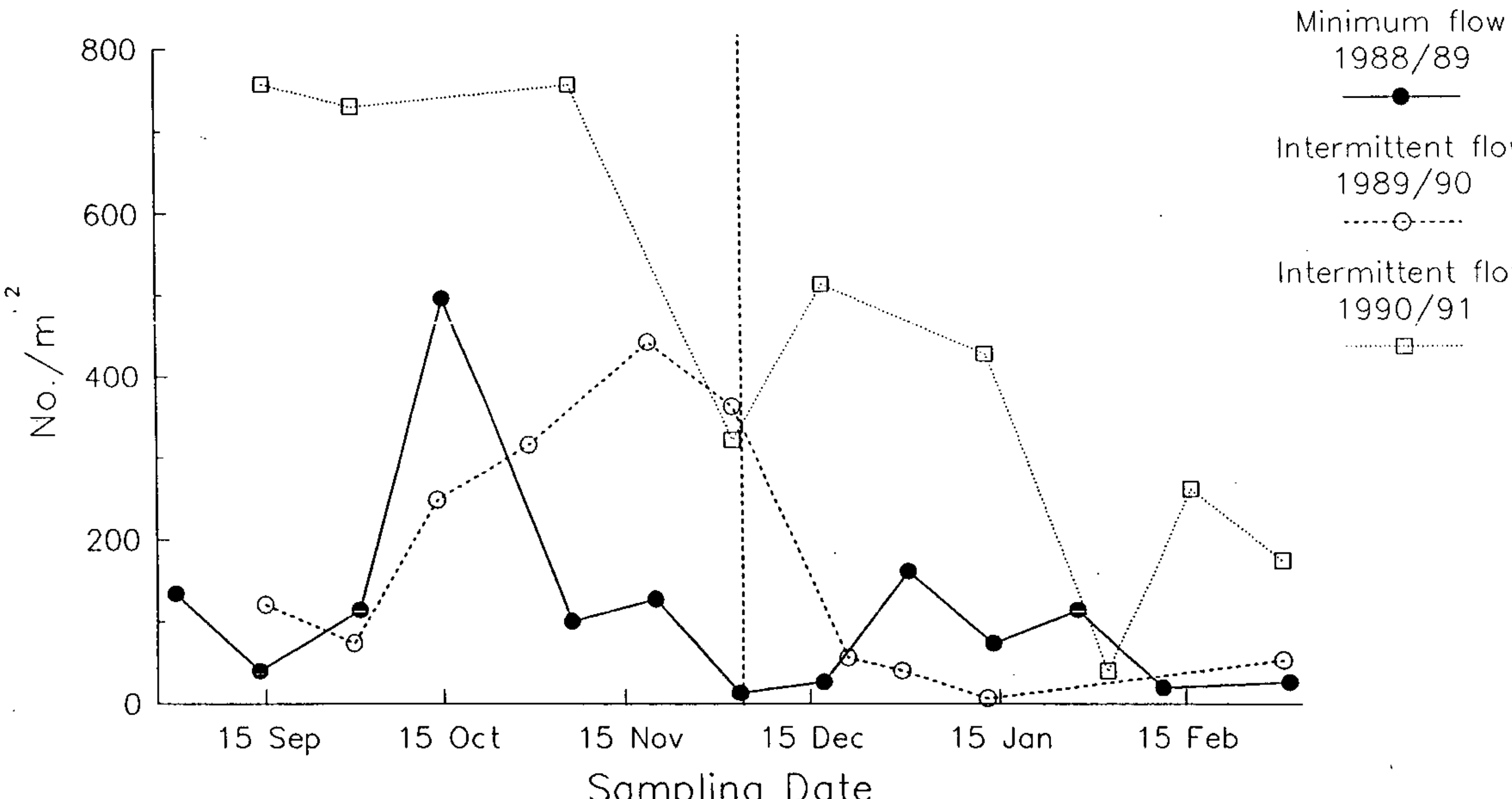

Figure B-4. Mean density of *Gammarus fasciatus* (amphipod) from bedrock substrate below Conowingo Dam. The dashed vertical line indicates the date of onset of the experimental flow period.

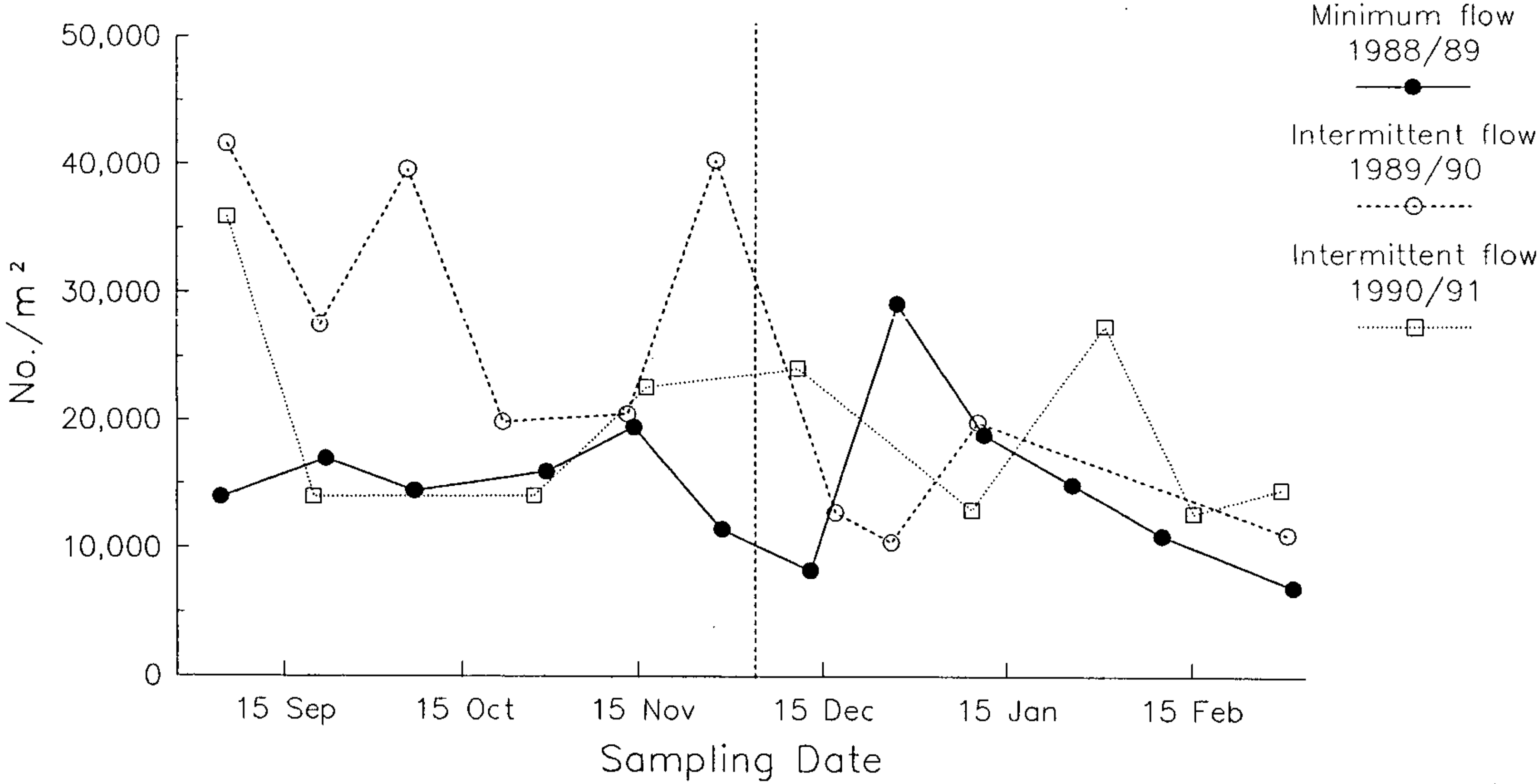

Figure B-5. Total mean abundance of macrobenthos collected from gravel substrate below Conowingo Dam. The dashed vertical line indicates the date of onset of the experimental flow period.

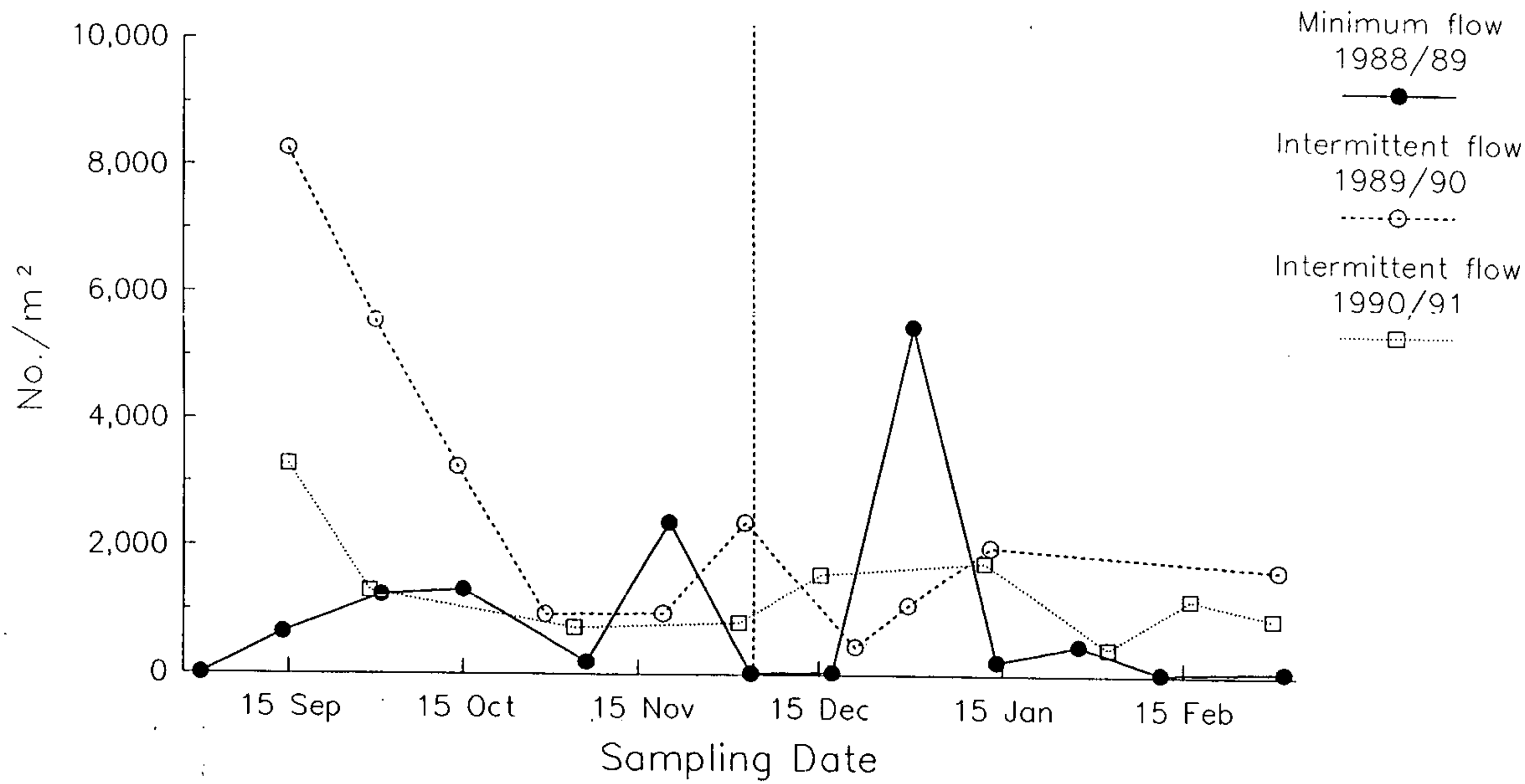

Figure B-6. Mean density of *Cheumatopsyche* sp. (caddisfly) from gravel substrate below Conowingo Dam. The dashed vertical line indicates the date of onset of the experimental flow period.

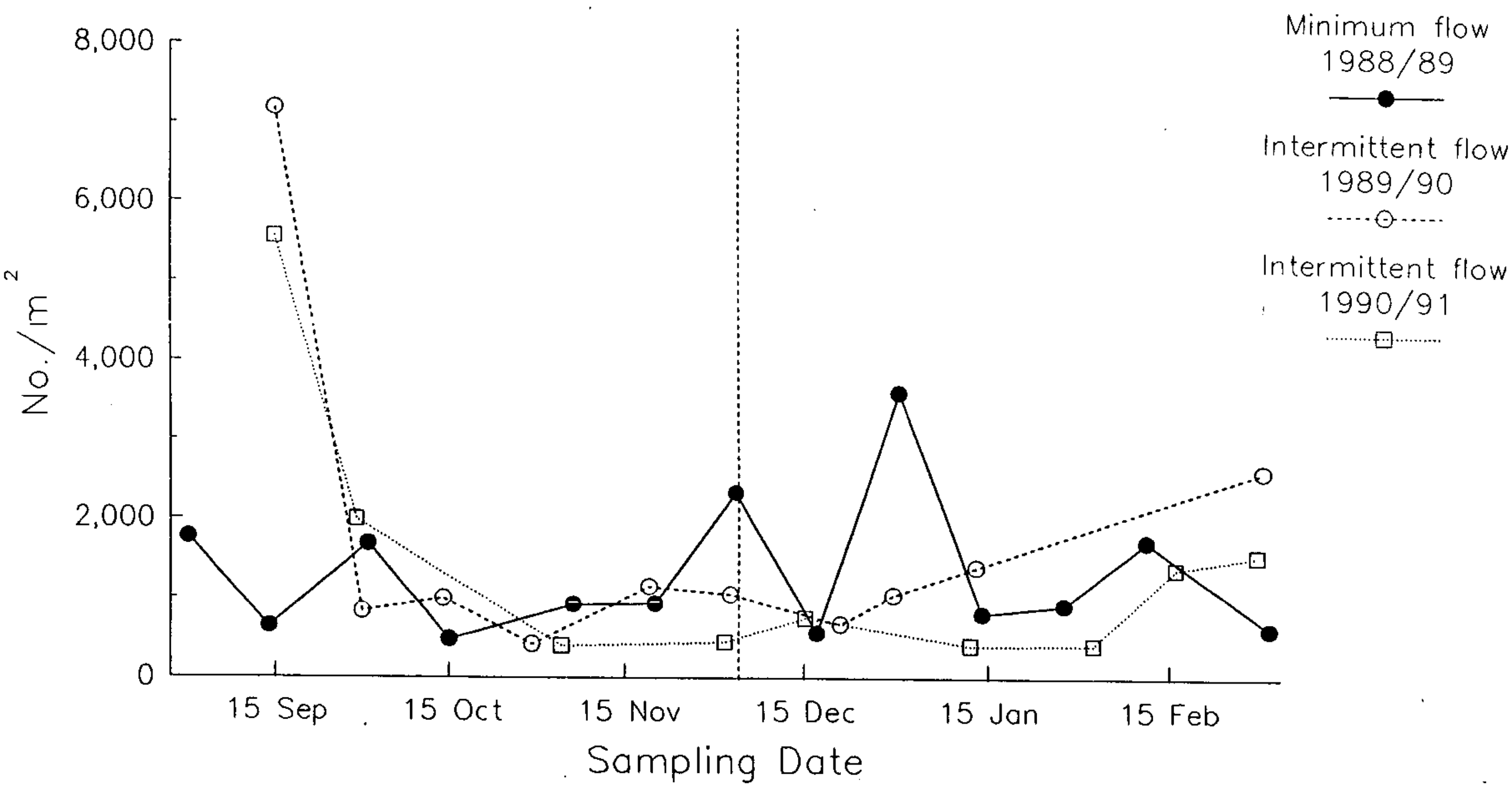

Figure B-7. Mean density of Chironomidae (midge) from gravel substrate below Conowingo Dam. The dashed vertical line indicates the date of onset of the experimental flow period.

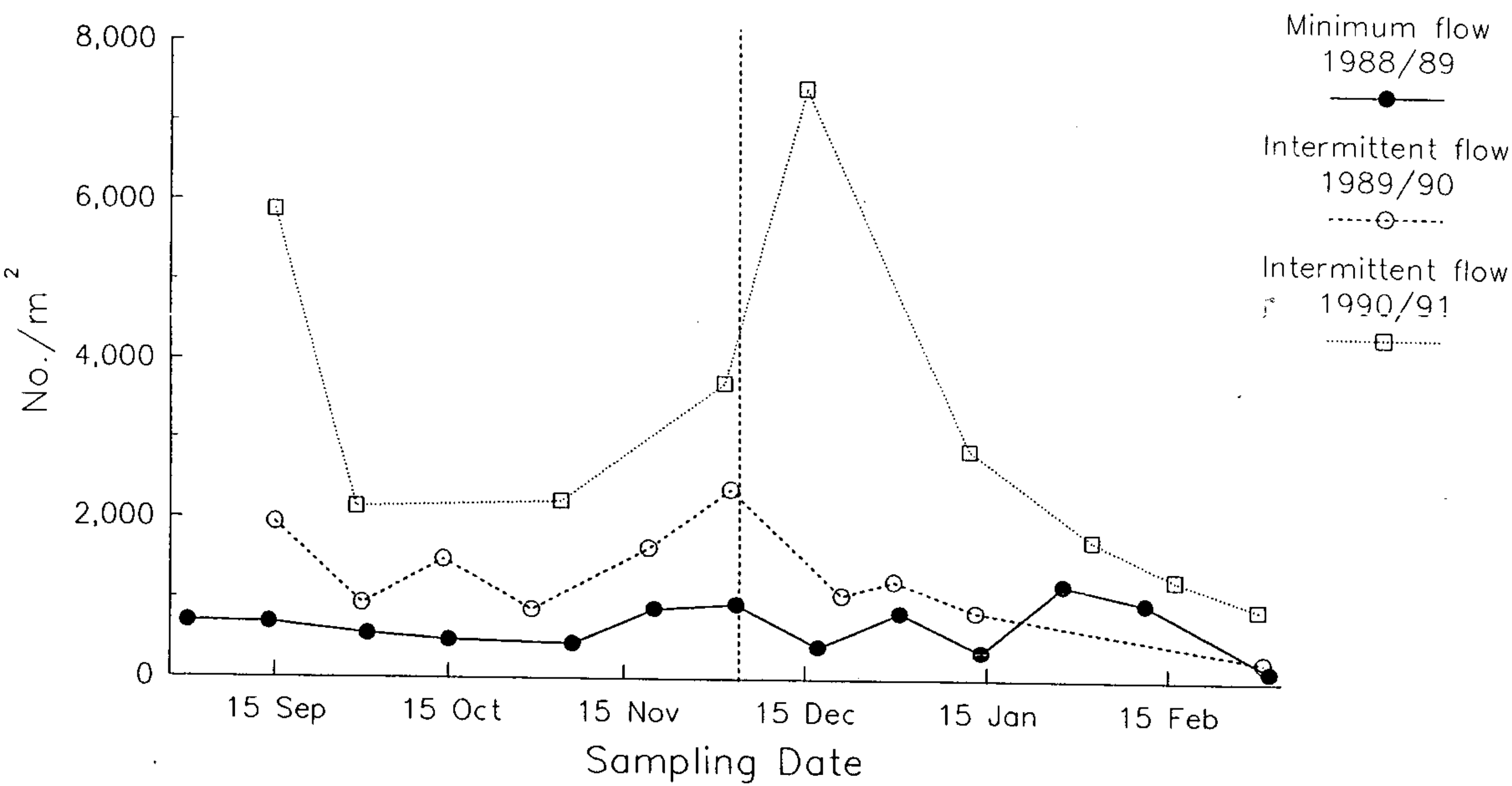

Figure B-8. Mean density of *Gammarus fasciatus* (amphipod) from gravel substrate below Conowingo Dam. The dashed vertical line indicates the date of onset of the experimental flow period.

APPENDIX C
KEY TAXA GRAPHS COMPARING THE INTERMITTENT FLOW REGIME WITH THE FIRST NO-FLOW TEST YEAR (1991/92)

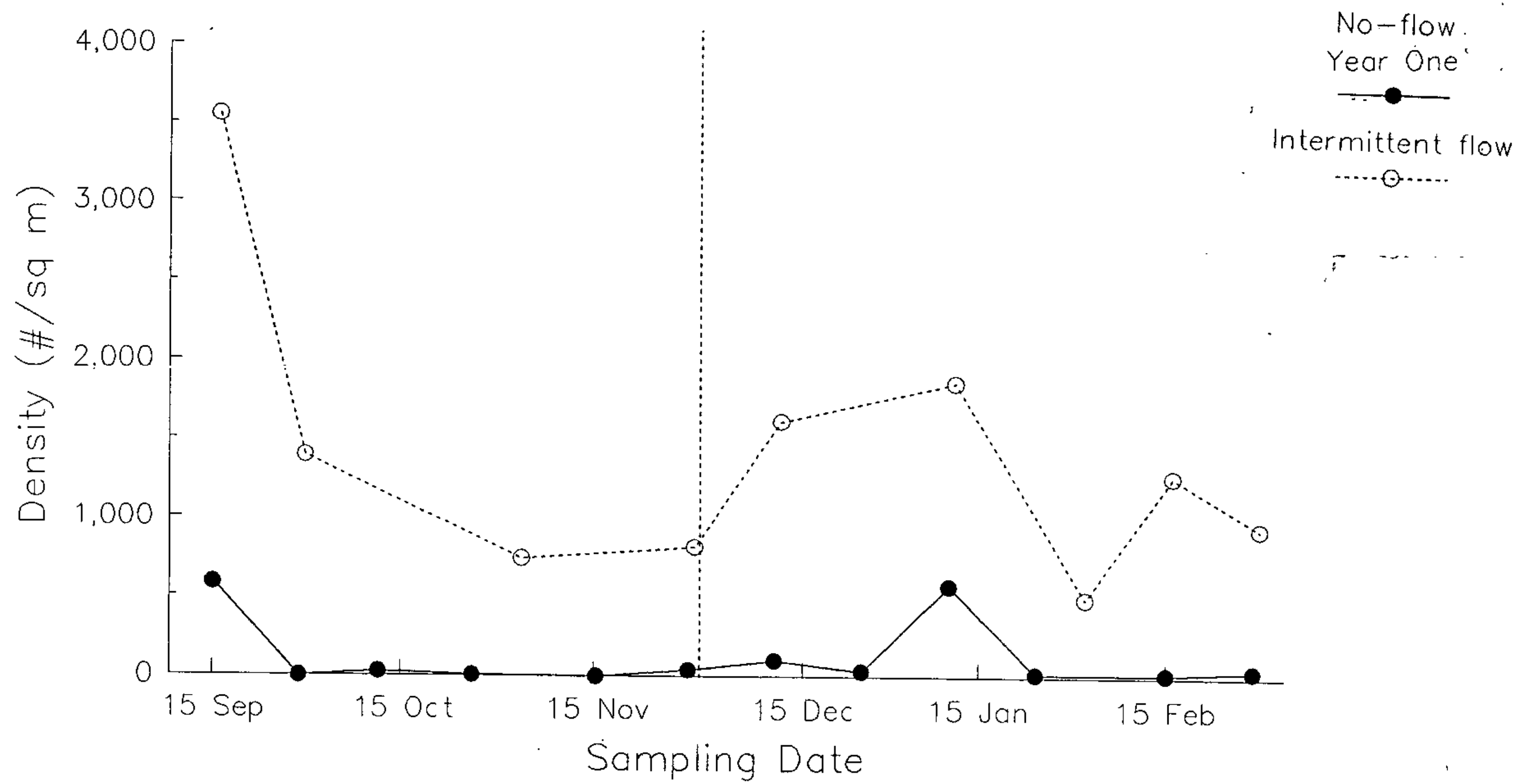

Figure C-1. Mean density of Hydropsychidae from the gravel substrate below Conowingo Dam. The vertical dashed line indicates the onset of the test flow regime period.

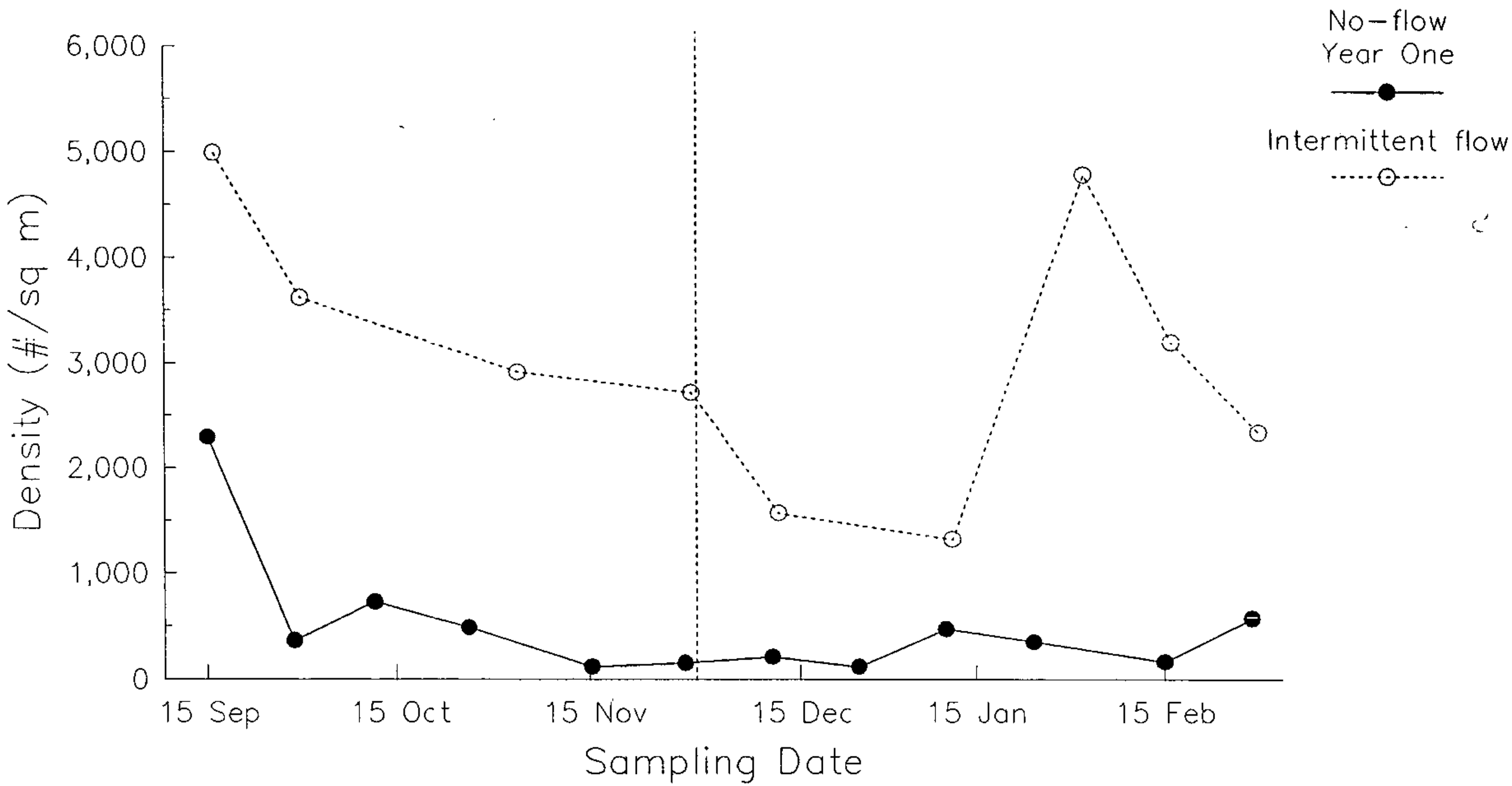

Figure C-2. Mean density of Chironomidae from the bedrock substrate below Conowingo Dam. The vertical dashed line indicates the onset of the test flow regime period.

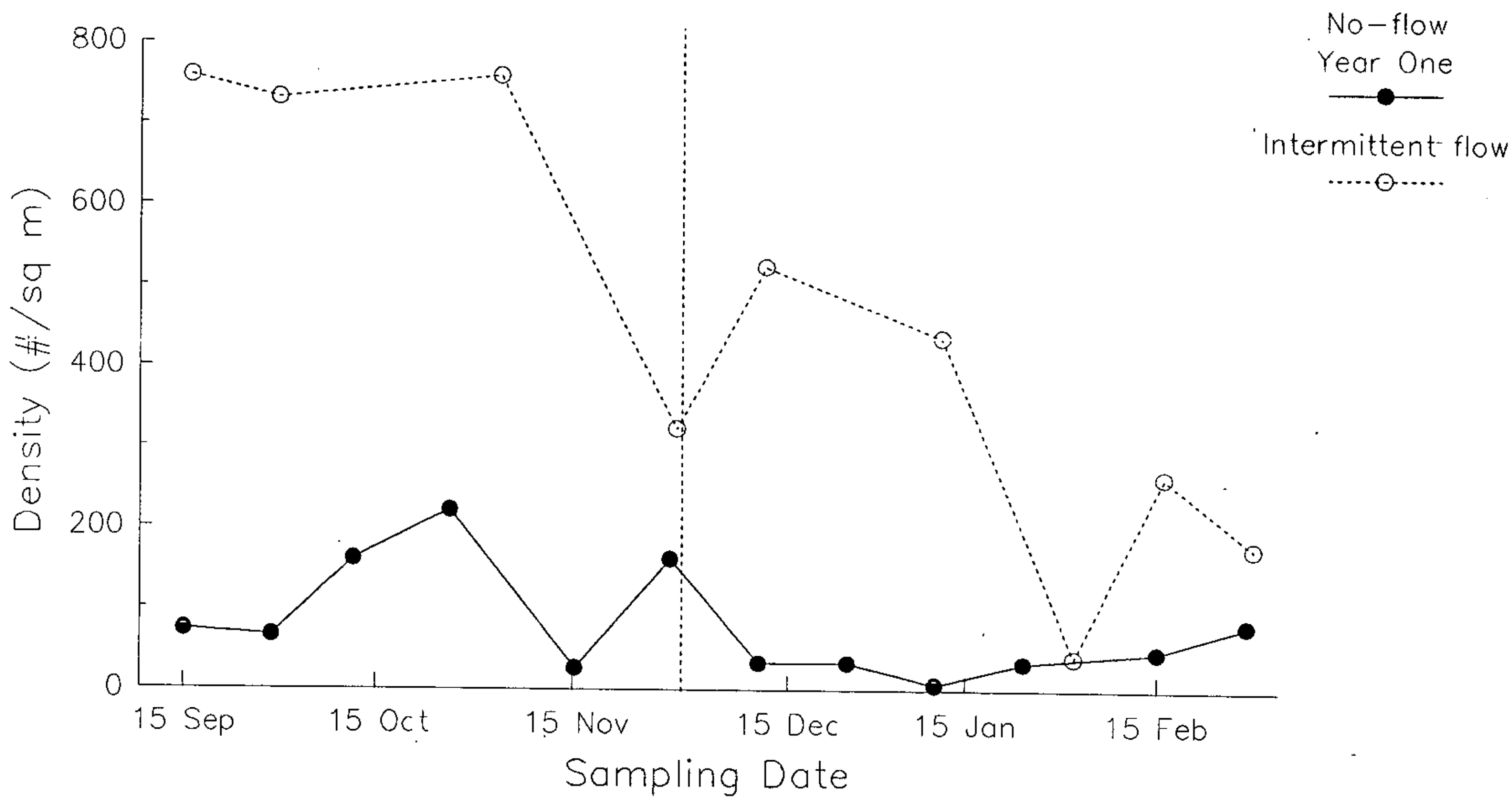

Figure C-3. Mean density of Gammaridae from the bedrock substrate below Conowingo Dam. The vertical dashed line indicates the onset of the test flow regime period.

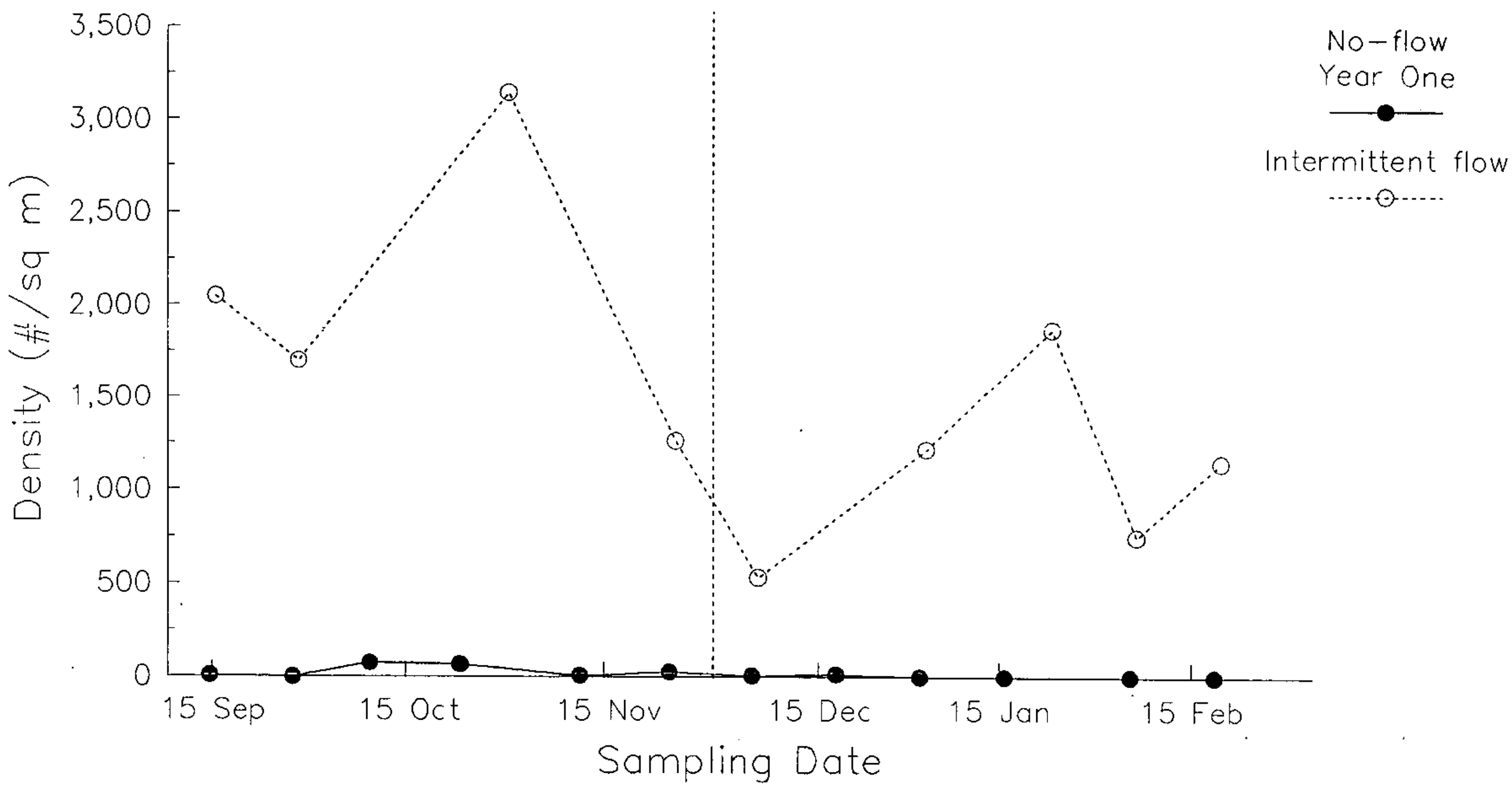

Figure C-4. Mean density of Hydropsychidae from the bedrock substrate below Conowingo Dam. The vertical dashed line indicates the onset of the test flow regime period.

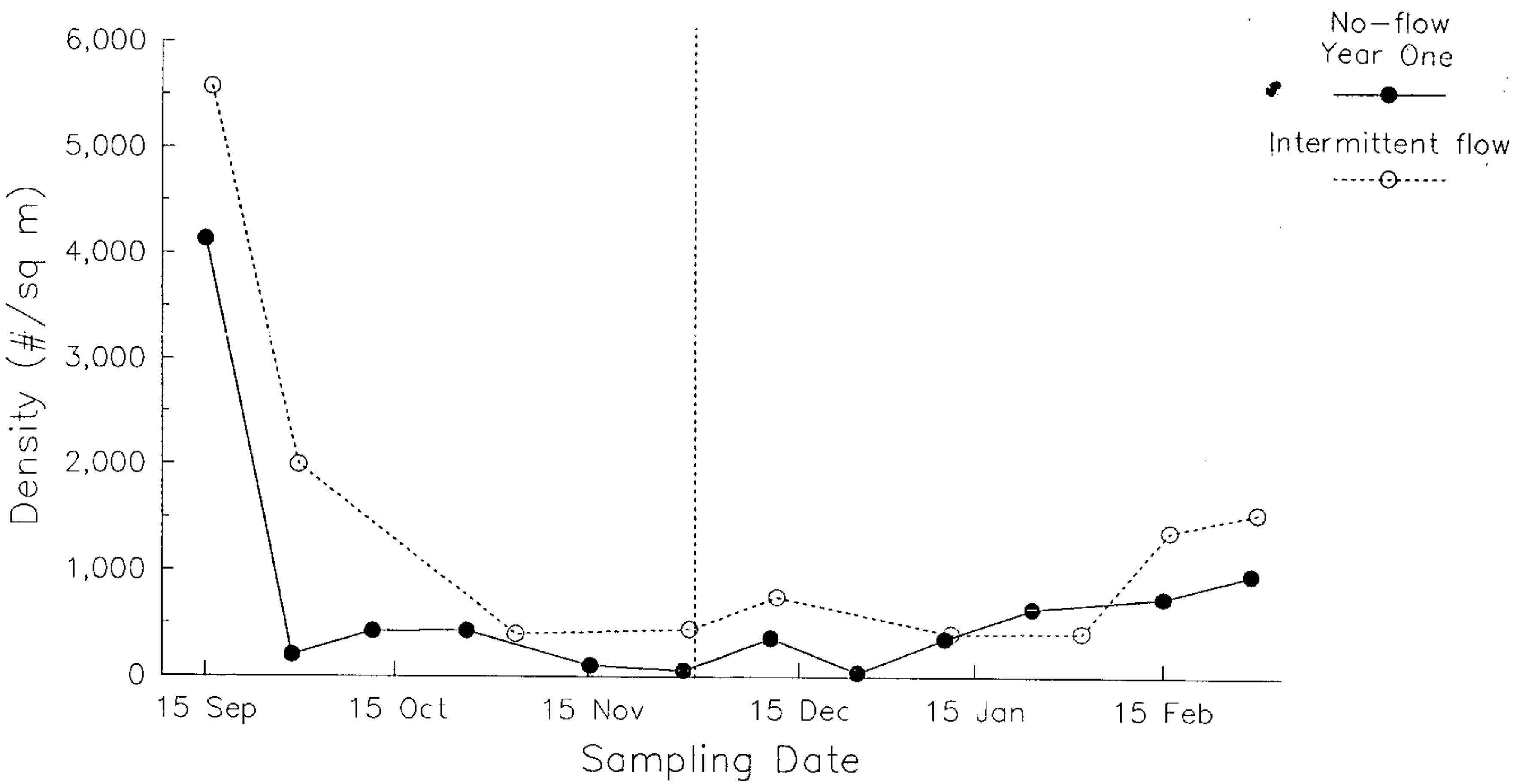

Figure C-5. Mean density of Chironomidae from the gravel substrate below Conowingo Dam. The vertical dashed line indicates the onset of the test flow regime period.

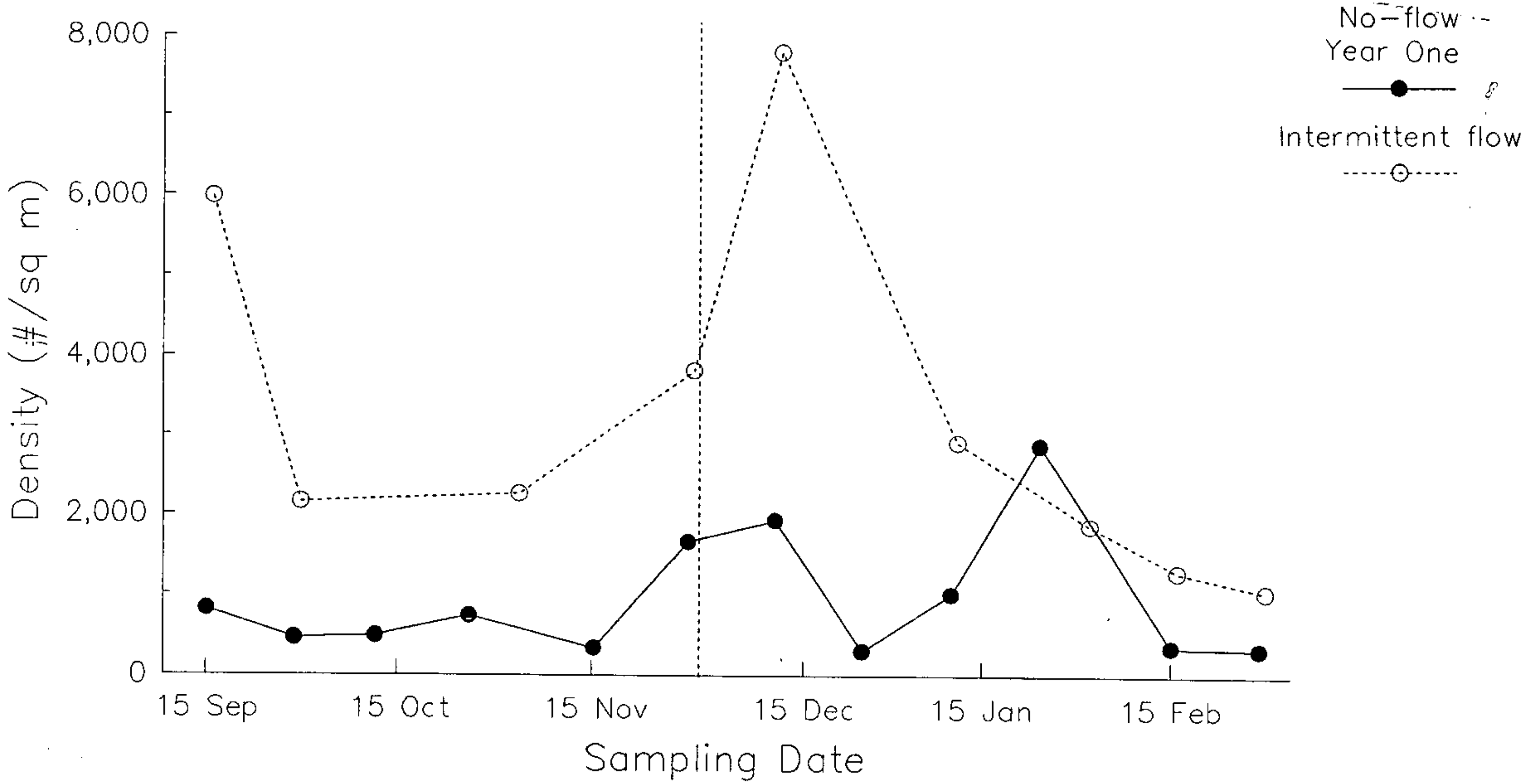

Figure C-6. Mean density of Gammaridae from the gravel substrate below Conowingo Dam. The vertical dashed line indicates the onset of the test flow regime period.